Ecological Flows Science Advisory Board

Meeting Summary – January 17, 2012
Archdale Hearing Room - Raleigh NC

	Distributed 2/8/2012, Due for Comment 2/17/2012 (COMPLETED)

X	**APPROVED for distribution Feb 21, 2012**

Attendance

Members

Donnie Brewer, Environmental Mgt Commission
Mark Cantrell, US Fish & Wildlife Service
John Crutchfield, Progress Energy Carolinas
Tom Cuffney, U.S. Geological Survey
Linda Diebolt, Local Governments
Chris Goudreau, NC Wildlife Resources Commission
Jeff Hinshaw, NC Cooperative Extension
Jim Mead, NC Division of Water Resources
Sam Pearsall, Environmental Defense Fund
Judy Ratcliffe, NC Natural Heritage Program
Jaime Robinson, NCAWWA-WEA
Jay Sauber, NC Division of Water Quality

Alternates

Jessi Baker, NC Marine Fisheries Commission
Cat Burns, The Nature Conservancy
Peter Caldwell, USDA Forest Service
Vernon Cox, NC Department of Agriculture
Sarah McRae, US Fish & Wildlife Service
Steve Reed, NC Division of Water Resources
Fred Tarver, NC Division of Water Resources
Holly Weyers, U.S. Geological Survey

NC Division of Water Resources

Don Rayno, NC Division of Water Resources
Sarah Young, NC Division of Water Resources

Guests (Onsite) :

Alissa Bierma, Neuse Riverkeeper Foundation
Sujit Ekka, City of Durham
Mary Freeman, U.S.G.S. Wildlife Research Center
David Gardner,
Dan McLawhorn, City of Raleigh
Ward Mamoth, WK Dickson
Kimberly Meitan, The Nature Conservancy
Ian McMillan, NC Division of Water Quality
Jennifer Phelan, RTI
Fred Royal, Brown & Caldwell
Amit Saehan, Parsons Brinckerhoff
Cynthia van der Wiele

Guests (Online):

Mary Davis, The Nature Conservancy/SARP
Rhonda Evans
Jennifer Everett
Morris Flexner
Lisa Gordan
Kyle Hall, Charlotte/Mecklenburg Stormwater
Lars Hanson, TJCOG
Paul Leonard,
Haywood Phthisic, LNBA
Peter Raabe
Nicole Schimizzi, NCDWQ
Erin Wynia
Rosemary ?

Facilitation Team

Mary Lou Addor, Natural Resources Leadership Institute (NRLI)
Patrick Beggs (WECO) Watershed Education for Communities and Officials
Christy Perrin (WECO) Watershed Education for Communities and Officials
Nancy Sharpless, Natural Resources Leadership Institute (NRLI)

THE PURPOSE OF THE ECOLOGICAL FLOWS SCIENCE ADVISORY BOARD:

The Ecological Flows Science Advisory Board will advise NC Department Environment and Natural Resources (NCDENR) on an approach to characterize the aquatic ecology of different river basins and methods to determine the flows needed to maintain ecological integrity.

Presentations, reports, and historical information about the E-Flows Science Advisory Board including how to sign up for the public listserv are available at the project website: www.ncwater.org/sab

Next EFSAB Meeting will be: Feb 21, 2012 @ 10:00am Archdale Building Hearing Room

MEETING AGENDA AND TABLE OF CONTENTS

DECISIONS MADE AT JANUARY 17, 2012 MEETING:

- Focus presentations on stream classifications.

EXECUTIVE MEETING SUMMARY

Mary Freeman, with the USGS Patuxent Wildlife Research Center in Athens, Georgia, provided a presentation to the EFSAB on a **USGS Science Thrust Project – Water Availability for Ecological Needs**. The project goal is to develop a scientific basis for predicting ecological consequences of water supply development in a river system. Mary's presentation focus on at least three areas:

1. Stream-ecology and flow relationships based on the Appalachian Chattahoochee Flint Basin (ACF) research
2. Transferability of species preferences
3. Defensibility of ACF work in context of controversy (over water use)

All three of these areas are covered in detail. Following Mary's presentation, the **EFSAB discussed the relationship between biology and flow and how to develop a methodology for determining ecological flow that accurately reflects that relationship.**

Observations discussed:

1. Mary Freeman's presentation points to the two tracks that keep coming up: the habitat approach and the approach of trying to assess correlation between biological data and flow alteration. Each has its pitfalls:
    a. Transferability: some comfort extrapolating from one site to another (as would be done with the habitat approach) for fluvial specialists, not so much for the non-specialists.
    b. With the biological data track, there is a lot of "noise" in the data, especially since the data were not collected with this particular use in mind.
2. In the habitat approach, look more closely at the riffle dwellers and how they respond to flow.
3. Suggestion is to focus on those most sensitive species and pick out riffle specialists if possible. Shy away from the generalist; get at those species most profoundly affected by changes in flow.

4. Focus on the base and low flows, not so much on the high flows.
    a. If withdrawal dampens the high flow in a way that has implications for populations and the focus is solely on withdrawals at low flow, monitoring results could be skewed.
    b. Yes, but it would have to be a big withdrawal and a big withdrawal would be on a stream with a high flood flow.
5. Classification:
    a. There was a much better relationship between size of withdrawal and the ecological response in smaller streams than there was in larger streams, so maybe stream size will be important in how we classify streams. It does with the currently proposed classification system because it is based on hydrologic statistics.
    b. The classification system we are using now does not get at persistence; we need to ensure that populations are persisting over time; that reproduction and colonization processes are sustainable.
    c. We need to evaluate our classification scheme and assess:
        - What are the habitat characteristics associated with each of the classes?
        - What are the biological characteristics associated with those classes?
        - What are the responses that you get out of the PHabsim?
    d. If the variability within classes is as large or larger than the variability among groups, we need to modify the classification scheme. If the variability within a class is less than between classes, then the classification scheme is working. We need to assess this before we can make any meaningful progress.
    e. We should test out the hydrologic classification system we have for biological fidelity.
        - Data from several projects are being pulled together under one initiative to figure out whether or not species and guilds show a strong degree of correlation with our classes. We are looking at strategies for testing fidelity. In addition to the EFS classification, we are going to look at the Konrad and McManamay classifications.
    f. Consider classes based on hydrology and topographic variables, such that class is the independent variable and biological responses are the dependent variable. Then as water is removed, the change is in the independent variable as a response is considered from the dependent variable.
    g. If the EFSAB is not comfortable with the hydrologic classification, may need to consider developing a set of classes based on ecological variables instead.
    h. Testing of biological fidelity involves deciding which animal groups. Some will be more canary-like than others meaning they will turn out to be more sensitive to modification of the variables that define the class than others. If so, the task then is to determine which are the more sensitive species and what the limitations are for them to persist.
    i. Let's look at various possibilities for classification schemes through the work others are doing.
    j. I am now persuaded that a pure hydrological classification that does not include topographic variables is inadequate, and I think that we need to do is figure out a way to incorporate them.
    k. There is an infinite number of possible classifications; that's the nature of classification. The important step is determining what the classifications will be used for and meets the needs of DWR. It appears what DWR needs is a way to say that if a particular site falls into a class, there are these expectations regarding ecological response to withdrawal for that class, rather than having to individually assess thousands of sites across the state.
    l. Let's determine what this group [the EFSAB] needs in terms of evidence to be able to buy into the classification system we already have. Questions to explore:

- What do we have in terms of channel geomorphology within these different classes so we know how variable they are?
- What does the biology look like, not just in terms of species, but in terms of functional guilds?
- What habitat suitability curves are available? Are we using the same curves everywhere?
    - So far and to a large degree we are going to use the same ones at all the sites. I think it helps if we think about them as not so much what happens to this species but, instead, how do the physical conditions in the stream change in response to a change in flow.
- Let's consider the 80 and 120 percentiles in our assessment.

m. Let's assemble all the information needed about the classes, look at this information and determine what additional information we need.
n. We developed the classification system we have because at lots of places we will not have any on-the-ground data other than what flows the OASIS model produces (hydrologic statistics).
o. There could be advantages to including factors such as channel condition or gradient, but realistically can we gather that for our modeling and planning purposes?
p. How often do we see shifts in classifications within a given stream network? To me if it happens a lot, then the utility of our classes is questionable.
    - We are interested in developing a color-coded map that would allow us to see if a given stream maintains its classification so some point then changes to something else.
    - Biological fidelity may not change as quickly as stream classification might.
q. I suggest we may need fewer classes, and let's pair up to biological data.
r. How about a rating system instead of going alphabetical, go numerical?
    - We have considered getting away from the narrative descriptors.
s. The whole process of evaluating the classifications is not just biofidelity; it is "what else do we know about these classes that might affect the interpretation of eco-flows?
    - Do we have this information
    - Where are the gaps?
    - Where are the sources?
t. We need to identify which are the most sensitive species and/or guilds for each class (whatever classification strategy we use).
    - Use those indicator species to craft the ecological prescription for each class.

During the latter part of the agenda, remaining time of the agenda, the **participants heard from Tom Reeder about his perspective on the role of the EFSAB and the current achievements of the board**. Tom believes what the EFSAB is trying to accomplish is unique; something others states have tried and given up. The EFSAB is trying to come up with a purely scientific non-political answer to what the ecological flow should be for the water bodies of NC. It is very difficult to do this right, to try to do something that is scientifically defensible. The Environmental Review Commission is very pleased with the EFSAB's progress.

The EFSAB is asked to keep the following in mind: 1) there was no mandate for how long this Board could meet and it may work into three years; 2) DWR does currently use a presumptive standard such that for any project that will use more than 20% of the 7Q10, a site-specific study is required before DWR will sign off on their EA or EIS; and 3) the EFSAB has accomplished a lot in a year's time:

a. The EFSAB's critique of the EFS classification led DWR to make changes to their classification scheme.
b. The EFSAB has developed two paths to pursue.
c. Fidelity testing is being done, and that will clarify what path to take.
d. Once the path, or model, is determined, then the matter comes down to determining the threshold of change that means that the ecological flow is being degraded and we have to take some sort of action.

The EFSAB is developing the science that will determine if projected uses of our river basins are going to have a negative impact on the aquatic ecology. Tom believes that what the General Assembly does with that information, and how they react to that information as policy will involve having a separate group to determine what that policy should be.

I. WELCOME, AGENDA REVIEW INTRODUCTIONS, LOGISTICS

Patrick Beggs welcomed everyone to the 10th meeting of the NC Ecological Flows Science Advisory Board. Everyone attending the meeting, in person and online, introduced themselves and their affiliation. The EFSAB was reminded about the ground rules, the process for raising questions, and reminded to speak into the microphone when raising questions. Everyone was reminded that the session was being recorded.

The EFSAB discussed changing the current meeting time from 12:30-4:30 pm, to 12:00 -4:00 pm. Some members would like to meet longer but there was no push to begin at 12:00 pm. However, the EFSAB would like to reserve the right to change the meeting times for any upcoming meetings including the start and finish time to suit the needs of future agendas. (Note: the start time for the Feb 21 meeting was changed to 10:00 am).

The remaining 2012 meeting dates and meeting locations are listed below (this information is also posted online at **ncwater.org** in the EFSAB section). The facilitation team is looking into new meeting locations with free parking and ample facilitation meeting space whenever possible and thus the following meeting locations may be subject to change:

- **April 24, 2012** - Wake County Agriculture Services Building, Room 107
- **May 29, 2012** - Stan Adams Training Center, Jordan Lake Educational State Forest (tentative)
- **June 19, 2012** - Wake County Agriculture Services Building, Room 107
- **August 28, 2012** - Archdale Building Ground Floor Hearing Room
- **Sept 25, 2012** - Stan Adams Training Center, Jordan Lake Educational State Forest (tentative)
- **October 23, 2012** - Wake County Agriculture Services Building, Room 107
- **November 27, 2012** - Archdale Building Ground Floor Hearing Room

The EFSAB was provided with notepaper. Since a significant portion of the meeting would be devoted to a discussion about the biology and its connection with ecological flows, the EFSAB was asked to write down any questions or topics that they would like to discuss later in the agenda.

Each presentation would be debriefed using the **Focused Question Discussion format.**

The Focused Question Discussion format allows the facilitators to capture key thoughts and discussion points, any remaining questions and concerns, and to list any actions or decisions. The facilitation team uses these questions to help guide discussions.

1. Clarification- the facts: *What questions of clarification do you have?*
2. Reflective- emotions, associations: *What is your reaction to the material/methods presented?*
3. Interpretative- insights: *What are the implications for the EFSAB's work?*
4. Decisional- next steps: *How can we use this information going forward?*

(Adapted from the "Focused Conversation" method by the Institute of Cultural Affairs)

II. REVIEW OF NOVEMBER 15, 2011 MEETING SUMMARY

The November 15, 2011 Meeting Summary was distributed for a final review following the January 17 meeting and will be posted on the NCDENR website by Jan 31. All 2010 and 2011 Meeting Summaries of the EFSAB are located at:
www.ncwater.org/Data_and_Modeling/eflows/index.php?tabid=1&subtabid=1

III. USGS SCIENCE THRUST PROJECT - WATER AVAILABILITY FOR ECOLOGICAL NEEDS Presenter: Mary Freeman (USGS - Patuxent Wildlife Research Center)

Mary Freeman, with the USGS Patuxent Wildlife Research Center in Athens, Georgia, provided a presentation to the EFSAB on a USGS Science Thrust Project – Water Availability for Ecological Needs. Mary's presentation is posted online in pdf format (listed as a January 17 presentation) at:
www.ncwater.org/Data_and_Modeling/eflows/index.php?tabid=1&subtabid=2

Mary is a research ecologist. Her realm of expertise is in stream ecology with a focus on stream fishes. Mary has been affiliated with USGS for 20 years (initially with the US Fish and Wildlife Service), and has focused her work on the effects of hydropower leases on downstream communities, and water withdrawals on downstream communities and land use changes. Her work was designed to inform conservation management and conservation decisions.

Presentation Overview:

The EFSAB had requested that Mary's presentation focus on at least three areas **(slide 1):**

1. Stream-ecology and flow relationships based on the Appalachian Chattahoochee Flint Basin (ACF) research
2. Transferability of species preferences
3. Defensibility of ACF work in context of controversy (over water use)

Stream-ecology and flow relationships based on the Appalachian Chattahoochee Flint Basin (ACF) Research

Mary began her presentation discussing the ACF research that she and colleagues had been researching. About six years ago, she and others were asked to complete a study in the Upper Flint basin (**slide 2**). This was to be a science thrust project; the researchers were asked to push the science

for predicting ecological consequences of water supply development; particularly how the researchers could best predict what outcomes there might be, given different choices in how water supply system might be developed. The Upper Flint was chosen in large part because its headwaters are located near Atlanta. The Upper Flint Basin, is literally by Runway #5 at the Atlanta Airport, and turns into a beautiful river that flows down and crosses the fall line before it hits the first dam. A part of the researcher's charge was to conduct the project in two years and use existing data (no fieldwork).

Other project researchers included: Brian Richter (Nature Conservancy, focuses on instream flow issues), Tom Annear (was President of the Instream Flow Council), Rob Jacobson (USGS geomorphologist), Brian Hughes and Lauren Haye (USGS hydraulic modelers), and Jim Peterson (Georgia Co-op Unit). Both Mary and Jim were charged with trying to tie biology into changing flows and determining how they would go about that.

Mary had previously done a study for the state in the Piedmont region of Georgia, looking at downstream water supply withdrawals for municipal use **(slide 3 & 4).** She sampled about 27 differing withdrawals that varied from very small withdrawals in big streams to large withdrawals on smaller streams, and then looked at fish communities, testing a hypotheses about whether fish that were persisting downstream from those withdrawals would relate to how much water could be taken out related to the size of the stream (this is X-axis is here). Of the 27 streams, one stream had a gauge so the study was limited in gauged data. Instead, there were estimates from low flow profiles that the USGS had done about the 7Q10 flow.

How low did the flow get in that 10-year statistic? **(slide 5).** The researchers took the permitted withdrawal size and divided it by the 7Q10. *What proportion of the 7Q10 was permitted for withdrawal across these sites?* In this graph, there is a species richness of generalist fishes, which was about half of the total fauna. In some places, there are almost 20 species or so. For sunfishes, and some of the catfishes and bass that can live equally well in reservoirs in streams, there was no relationship. Moreover, some of these sites were just downstream from a withdrawal. There was a pipe in the stream and others were downstream from an impoundment that water was taken out of though the researchers were not sampling the stream part. There was no relationship.

However, if one looks at the fluvial specialist species, there was relationship and good evidence for a decline in species richness if the relative size of that withdrawal was increased. This was helpful data but not a flow statistic. Increasing the amount of water that can be taken out of a stream has the potential to change many things about flow; as researchers, we were not measuring that (there was no gauge data).

In addition to Mary's work, Jim Peterson had been working in the Lower Flint. His study was about three years old and he had something close to 30 sites. His sites ranged from large streams to smaller ones; his study focused on changes in fish density. Jim's data was used to model how fish density changed in relation to how low the flows were during the spring and summer season for each of those three years. The point of these graphs is to show that during lower flow years and dry years, that fish did not drop off. However, in smaller streams, the drop off occurred more quickly. Jim's study design included two kinds of

channels, streams that were pretty deeply insized and streams that were not, but rather were shallow and easily connected to the flood plain (though they tended to dry up during those low years and thus one saw a greater change in unconfined streams than in the confined ones).

Mary reported that though both she and Jim had data, neither study could provide a basis for predicting how a system might change generally as things changed about a flow regime, whether a change occurred through land use, climate change, or because of water diversion. Given their charge, they brought a group together to consider how to develop a flow study about ecological responses to changes in flow regimes that focused on fish. Primarily, this study team started thinking about fishes in a range of streams including these small and medium streams that composed the drainage network. They broke flow regime into very basic components **(slide 6/slide 7):** large floods, small floods, high flow pulses, base flows, and extreme low flows (drought years) and explored how to tie these components into something about aquatic biota.

They framed their question as: How do those flow components affect biota? In other words, what would be the variables if a researcher wanted to develop a flow ecology relationship? In changing things about flow, what will change? What would the variables be, particularly in terms of the persistence of aquatic biota? Would the species that are there now still be there in the future? For persistence to occur, plants or animals have to be able to survive on a site and they have to be able to reproduce on a site, and if they cannot do either or both of those things, they have to be able to colonize it from time to time in order to persist.

A biological community at any given site is going to be a function of what the channel is like. What kinds of habits are present? Habits are influenced by water quality, such as temperature and dissolved oxygen and perhaps contaminants. Channel conditions, especially in the Piedmont of Georgia and the Piedmont of North Carolina, are affected by historic land use and direct channel modification. Hence, any study being developed would need to consider context. Water quality could be affected by landscape changes, including runoff and wastewater discharge.

The study team conducted a literature review of a number of publications from the last few years relating flow regime to various ecological aspects of streams **(slide 8).** The lit review supported an understanding that water flow in a stream is affecting transport of materials, it affects processes, and it affects habitat structure and disturbance **(slide 9).** For example, floods bring in sediment and wood which affects channel condition. The small floods down to extreme low flows are affecting stream flows by influencing organic matter transport (foodstuff going downstream). They affect nutrient availability, which may be exacerbated during those extreme low flows, especially if you have wastewater discharge coming in. Processes include riparian processes, tree recruitment and growth, vegetation processes, decomposition on the riparian zone that then affect sediment and wood coming in. They affect things like spawning and migration cues, and high flows that bring fishes upstream to their spawning sites. Those things all affect biological productivity - the ability of plants to grow, animals to feed, animals to reproduce, produce young of year **(slide 10).**

Habitat volume: habitat structure and habitat dynamics has been the basis for a lot of thinking about flow effects on streams for a long time or IFIM (Instream Flow Incremental Methodology) **(slide 11).** IFIM essentially takes flow and relates it to changes in habitat volume, which should directly affect persistence of aquatic biota as well as productivity. Disturbance was related to high pulse flows even though large floods and small floods can be disturbances as they physically remove plants and animals from the system **(slide 12).**

Many things affect persistence of aquatic biota including land cover dynamics, water withdrawal, climate change, and stream impoundment **(slide 13).** Stream impoundment also affects reach isolation, because as a system becomes more impounded it also becomes more fragmented **(slide 14 and 15).**

Mary introduced the study approach and the model developed for the study – how to get from here to there, what affects those things, and then bring the findings back to a management application. The model was a simplistic representation of how one might view flow regimes affecting things in streams (though it was unworkable in that data would not allow the researchers to, for example, tie flow to organic matter transport quantitatively and then quantitatively relate that to biological productivity **(slide 16).** What the researchers do have are observations of "who" persists in streams and a little bit of data through time (such as Peterson's data from the Lower Flint of year-to-year changes), and thus researchers can think back to those processes that are driving these changes.

Using direct connections, the researchers came up with a simpler model that could consider flow regimes tied to persistence of fishes and mussels and other critters. Persistence in this case related to colonization, the ability of animals to move into a site; recruitment or reproduction; in other words, biological productivity, and then persistence within the site, related back to those differing flow components. The conceptual framework was to model the hydraulic regime using scenarios. These scenarios could include a future climate, a future land use land cover, a future water management action, or all of them together; whatever was of interest. By introducing scenarios onto a landscape and modeling the resulting flows, links to some key processes *could* be simulated. The process provides a way to simplify the system to allow simulation of effects and changes in flows. Persistence of given species or ability to meet a biological objective such as a biological integrity objective, while accounting for the actual channel morphology out there on the landscape and things about water quality, is part of this simulation.

The next step, according to Mary, is to actually parameterize a model in order to tie flows to these things that fish do. Jim's data assisted with this; he suggested that, "Now I think we can do this if we think about it like this. Here's my stream network, for example, and if we think about a given segment of a stream, all the fishes that live in this stream network are unlikely to all be present in every stream segment at every point in time, so there's some turnover from year-to-year. Those are metapopulation dynamics. If you have this information, you can visit the same stream segment every year and see changes from year-to-year, changes we can think of as transitions" **(slide 17).** Mary provided a summary: "That is all to say that if a species is there the first year and you go back, and it's still there the next year, we're going to say it persisted (it's a probability that it persisted). If it's there, it may have the opportunity to reproduce, depending on what species it is – maybe every year, maybe only some years, but there is some probability of reproducing. Moreover, if you visit that stream in a year and it is not there, and you go back and it

shows up, then it is colonized. Therefore, **there are three transition possibilities and in some ways those are related to flow: persistence, reproduction, and colonization.** This was what we hypothesized and that's what all that modeling was about, was thinking about how flow can actually affect those things that fish do."

From the little bit of empirical data from South Georgia, Peterson said, "Well, from this data, let's model the probability that those things occurred across all the species that we observed." This included about 40 species of fish, and thus the probability is probably different, depending on what kind of species it is, given species traits involved. The difference may depend on the individual stream segment, whether it is a small stream or a large stream, and whether it was deeply incized channel or a broad and shallow channel that was used in the model.

Mary stated that it makes a lot of sense to consider location in the drainage network. The researchers hypothesized that closer to the main stem; it's easier for things to colonize. Mary said, "And then finally, the things that we were asked to think about were things about flow. So if you're representing these data, and you're looking at what kinds of changes happen through time, you can say, the bass persisted and it reproduced, and what was the flow regime in that year." And in another year, the bass…they didn't persist; they disappeared. What was the flow like in that year? Then in the third year, perhaps they colonized. You can say what was the flow like in that year? Fit some very simple regression models fitting the probabilities of these things happening to this stuff but also to the flow regime, what we were trying to get at. When Jim did that, he got some pretty good models, and what this is showing is the relative support for differing flow metrics driving those processes. For example… this doesn't mean extinction forever and ever. It means that the animals disappeared out of that segment."

Question: Local extirpation (vs extinction)?

MARY FREEMAN: It's like local extirpation. It could be related to medium flow or to the 10-day low flow; there's good support either way. Colonization was strongly related to high flows in the season's spring or summer, and reproduction was related to high flows when the animals were spawning, which might be a different period depending on the species, and they were related to this flow variability, the standard variation of flow. How flashy was the flow during rearing? Makes a lot of sense. We've seen this in some other studies that very flash flows like releases in hydropower dams, for example, sometimes animals have trouble recuperating because of all of that flow variability.

From the models the researchers got parameter estimates that said how much does the probability of extinction change for a given change in a 10-day low and how much does probability of colonization change for a given change in the 10-day high; this information was used in the simulation model **(slide 18).** The model itself is not complex but parameterization is a complicated process. In order to parameterize the model, the researchers took a particular basin subset, a sub basin within the Flint River using geologic and geographic data layers, the topography and the soils, and the impervious cover and vegetation. These elements were used in parameterizing the hydrologic model along with the time series of precipitation and temperature (a long period of time). This was modeled over 20

years, and included a distribution of precipitation runoff that applies rainfall onto the basin. It percolates; does all that stuff water does. It goes in the different components and it runs down to the streams and that's what they simulate and then calibrated this with a set of gauges down in the basin to have idea of how well the model was doing.

The model did well. The researchers used the same layers to classify channels, according to both small, medium, large streams and whether the channels were expected to be incised or not, to provide an initial distribution of what species were likely to be where, just based on empirical museum data – all of those things feed into that metapopulation model that just says, *"What's the probability in a given stream segment of persisting or not persisting or colonizing or reproducing from one year to the next given the flows and that kind of channel?"* What can be derived from looking at this question is a time series of species occupancy and it looks something like this **(slide 19).**

In this basin, there is a 500 square kilometer basin called Potato Creek. Every hunk is a stream segment which is color coded by projection, and species by species. In adding them up, how many species would be there in 1998, which as it turned out was right before a pretty big drought. Take another slice of the simulation – look at 2001, and the species richness mostly dropped except at the main stem, and then a few years later with another slice in 2004, there is a good bit of recovery in the system **(Slide 19)**. This is a simulation of how species are responding to changes in flow through time.

The flow statistics used to drive the simulation are there. These statistics represented major flow components: median seasonal flow as a measure of base flow, the coefficient variation of seasonal flow – that's how variable the currents of those high pulses can be – and then the very low seasonal 10-day minimum, seasonal 10-day maximum, the higher flows, and this minimum 10-day standard deviation – that's flow variability again. The flow model projects those from a daily flow model, which can be extracted for each season and then applied back to our probabilities with an indication of, "Here's what we think would happen."

So besides creating a good picture, what is this good for? Having this model in place, researchers can play "what if" games. Mary said, "So we can say…and we've done this. This is about as far as we got with the science thrust project. To then at the final point say, "Okay. Is it responsive?" If we go back and say, "The City of Thomaston is right in here someplace. Let's put in a withdrawal in the City of Thomaston, add that in and simulate what species would do." And so we did that. We said we could put in a 5 million gallon-a-day, or 10 or 20, or 40 million gallon-a-day withdrawal, simulate responses for 20 years and then ask on average how did differing species change in their distribution across that basin. Did they become less frequent? And that's represented here by this occupancy rate **(slide 20).** That's just the probability that a species would occur in any given basin. So what this is showing is that animals like mosquito fish do not care how much water you take out; they're fine. They did not respond at all; and pirate perch, not so much. The blackbanded darter and a redhorse sucker, showed greater decline.

Mary reminded the EFSAB that the researchers were asked to do a little more science rather than develop a decision support to them. The other thing about the model, it can be used to evaluate how sensitive the model is to a researcher's assumptions regarding the mechanisms **(slide 21).** For example, using the same

simulation to increase water from the basin. *How would you expect species richness to change?* This slide shows a decline in species richness as a percent, as water is withdrawn, and as more water is withdrawn, local extirpation can occur in a given year. With extirpation, there is the possibility for recolonization. It depends on the 10-day minimum flow in that year. Over a 20-day period, this is what you get.

Reproduction can be modeled two ways **(slide 22).** Thinking back to slide 21, and the bar graph, there was support for modeling as functioning variability of flow or high flows, and that's why there are two lines. It does not matter which way; a similar answer would be generated. Extinction is also related to the median flows in the given year. In real life data, years…medium flow and the 10-day minimum are likely to be pretty strongly correlated and so it shouldn't be a surprise that both would be supported in just an empirical model; difficult to go in and tease those things apart. We are not doing an experiment; it is based on correlation. The important thing is that if researchers model extinction as a function of the median flow, then there is a much less of a decline because water withdrawal is not affecting the median flow nearly so much as it is affecting the 10-day minimums. This is a real structural uncertainty. These kinds of differences reflect the level of uncertainty in the actual mechanisms underlying what has been observed.

This provides information about what might be considered for monitoring. For example, if it were a real management decision in the City of Thomaston, the need for 30 mgd. For researchers, this poses a good opportunity to monitor downstream from the withdrawal, and measure flows to collect data for future applications and develop a better understanding about future applications. Mary reported that as researchers, they are still studying the ACF **(slide 23).** The U.S.G.S. just initiated a new project in the ACF, the WaterSMART Program **(slide 24).** The program will allow the researchers to push a little bit harder and actually do some fieldwork. The ACF is an area of high controversy because it crosses three big broadly physiographic provinces, known for its richness in biological diversity. For a number of years, these states have been trying to figure out how they are going to share water.

There is another program, a project in the middle called SEAWRAP, designed to specifically model for climate change. Currently, USGS has hydrologic models for the whole ACF basin, including fine resolution segment-by-segment models for six differing sub basins. What USGS is doing as part of WaterSMART is putting in water use, since the models right now are based essentially on natural flow models. This will allow USGS to make these current condition flow models, and over the next three years, sample fishes and mussels in all of these areas. Right now the fish data – to parameterize that model – are all down here on the coastal plain, allowing the researchers to ask questions – whether those relationships are different in the Blue Ridge, the piedmont coastal plain and update that model with those parameters and then push the simulation a little bit harder, simulating biotic responses to flow alteration scenarios to try to get at some basis for management where one of the management objectives has to do with conserving biota.

For example, in the Potato Creek Basin **(slide 25)**, there is a decline of the fluvial specialists, a stream dependent species, and in all species versus the very generalist species in the simulation. One consideration for future applications is the possibility of using this simulation to develop guidance for environmental flows. Mary reminded folks, "The study I started out with where we worked below the

withdrawals in the bottom of the Piedmont of Georgia was basically a measure of scale of stream size to daily water withdrawal. There may be direct relevance of being able to take a basin of interest, and look at actual management kinds of actions directly as those relate to changes in biology, whether these are mussels, fishes, or just a measure of biological integrity. This continues to make a lot of sense to me but there is a push nationally to replace this access with direct measures of how much one changes differing flow components; the premise behind the ELOHA idea.

ELOHA is the Ecological Limits of Hydrologic Alteration **(slide 26),** based on the work of a number of authors/researchers. It was generally agreed among the scientists that "rules of thumb" would be difficult to defend without some kind of empirical data behind them. Mary clarified, "Let's identify predictable responses to flow alteration, parameterize them based on existing data, and use that as a guidance to identify ecological limits based on whatever the ecology objectives are; and put some quantitative data in there. Suspect Mary Davis went through a similar framework, with the idea that you'd start with original hydrologic models **(slide 27).** Well we have that now for the ACF. We identified stream types expected to respond differently to flow alteration, and developed a model of ecological responses to flow alteration for each stream type. Our original concept in the ELOHA is that a researcher could go to the files and get all this data that people have been collecting forever and plot the data –how much are the flows altered in a given spot? What is the biological community like? By looking at the response, there could be an idea about how much one can change flow regimes before getting a biological outcome that was not preferred. Couple that with whatever the objectives are; however much change in biology is acceptable; decide the flow requirements, and then most importantly, monitor the outcomes because there is always going to be enormous uncertainty in these things. Monitor outcomes and then use the data to improve your models as one manages iteratively through time. Is that kind of how Mary Davis told it? (Heads nodding). Okay. Good".

Mary Freeman identified problems with the ELOHA approach by stating that it would be difficult to pull quantitative relationships out of the data collected. Scientists conducted a review of 165 published papers **(slide 28).** Consistently, things were negative by someone's viewpoint; negative ecological changes as flows are altered, but what their studies show is that the curves go in every direction. They may all go down but at very differing rates. Thus, it would be hard to develop, based on the literature – transferable quantitative relations. According to Mary, "When you go out to a stream, and you take a sample, of the mayfly, stonefly, caddisfly species richness, these are indicator taxa. Many things influence a sample from a stream at any one point in time, besides flow. Flow certainly, but also other things. Moreover, if you kept going back to that stream year after year, you will see some variation within that stream. When you try to plot those points in time, the data against differing measures of flow, what you get are some really noisy data. This is a typical graph **(slide 29).** Konrad and other authors did this study with a very large data set from the Western U.S. This is not the worst graph but a typical graph, showing us how hard this can be. There's evidence of a decline in bug richness with increasing flow variability but it would be difficult to make a management decision from this information given the level of noise".

"This is where I really am intrigued with this simulation route, where if you can use your empirical data to directly estimate flow affects on processes and then use those processes in a simulation model to simulate how populations may change. If you could hold everything else constant but you were just

changing flow, "How big would that effect be?" So going back to our simulation approach, we might be able to simulate for those differing parts of the ACF, flow-ecology response curves for fishes certainly and perhaps mussels. I'll show a little bit about that, in differing stream types, based on flow effects on the underlying processes of survival, reproduction, and colonization, and so we may be able to predict; this is my goal at the end of the WaterSMART project, and why we want to push these simulation models a little more to see what we can do with them. Can we produce curves like this, say for different groups of species with differing characteristics and in differing physiographic settings, for large and small streams, and, through the miracles of simulation? If we put some error bounds on there, both as the result of underlying model uncertainty and the flow component you choose to drive that thing, then its just stochastic variation. So we know we can do this with the models. It's going to be relating it to a change in a flow component that I'm not yet positive is going to make complete sense. I think this still may make the most sense to relate it directly to management choices but they're all related. This is where we're headed" **(slide 30).**

About mussels, Peterson just published a paper looking at mussel responses related to hydrologic alterations. This is in one stream, the Sawhatchee Creek, near the Chattahoochee River down in South Georgia. Working with Jim is Jason, who worked with the State of Georgia as a mussel biologist; Colin Shea was a Ph.D. student and Rhett Jackson, a hydrologist at the University of Georgia. Jason had a 5-year mark-recapture study on mussels **(slide 31);** these were marked individuals that they went back seasonally and could directly estimate survival, and they could also look at recruitment in that population. After mussels were about two years old, they would start to pick them up so they could look at two of those processes in relation to changes and flow. The thing about mussels – is that metapopulation dynamics is slow. Mussels colonize infrequently and turnover can be long. A mussel might live 30 years, so the population might be functionally extinct or locally extirpated but you may know until the last one dies, so mussels are harder in that sense to work with than fishes. This is just in one stream; the three listed mussels were related to processes of survival and recruitment, to things about flow and in that situation survival was negatively related to the high summer flood flows.

Recruitment was positively related to flow in both spring and the summer, so they could estimate a population growth rate. Here, for example, in relation to summer median discharge and where this crosses one, the population would be increasing for summers with high, medium, and low survival, depending on that high flow. So again the power simulation is…there are empirical measurements allowing us to simulate how that population would do, given the median summer discharge, and in that paper, it is one that is worth looking at because it is good, but they also do some direct applications with this. For example, they can say, "As you were to increase water use, again out of Sawhatchee Creek, here's scale to the average annual discharge **(slide 32).** You take more and more of the average annual discharge, how would that affect the probability of extinction over a hundred-year period of those differing mussels just by changing the flow regimes?" They had four different models all with support from their empirical data – one of them does not show much change, three of them show big changes. So this model projects uncertainty again. These were the best models based on the empirical data. So this kind of thing could perhaps be of use in making these kinds of decisions if this is one of your management objectives – presenting extinction. I think that's all I was going to say about the ACF work.

Transferability of Species

There is a question about transferability of species, how transferable are observations for a fish in one stream to a fish in another stream **(slide 33)?** It's a good question often asked in relation to IFIM kinds of models where the researcher is able to model depth and velocities in relation to different kinds of substrate in the stream channel over a range of flows. If criteria is available for a particular species, the kinds of depths and velocities and substrate it likes, one can model the habitat, and perhaps scale maximum amount in relation to flow. Then the question is can one go to another river where there is the same species and use the same habitat model? It is a very interesting question.

Mary relayed how when she first joined the Fish and Wildlife Service, she was at Auburn University working for the Instream Flow Group, that her task was to try to do a study related to: "Are the depth, velocity and substrate criteria transferable for fishes between piedmont and coastal plain streams?" The response was that they could be very transferable. In this situation, there was good transferability for fish species that consistently use fast water habitats – the riffle species (bronze darter, lipstick darter and greenbreast darter, **slide 34).** If flows get low, they'll be in the fastest water that's available. In this case, there was good transferability but for other fishes, including stream dependent fishes and including other kinds of darters like the speckled darter, which are often in pools and in riffles, transferability based on the stuff usually use – depth velocity, substrate criteria were not good. There was poor transferability in that case. So it depends on what kind of critter is being researched.

The question about transferability sent Mary to the recent literature where transferability receives a good bit of discussion. For example, about macroinvertebrates and bugs in the stream **(slide 35).** In some cases, there can be very good transferability of criteria based on sheer stress at the bottom near substrate hydraulics. Bugs that like really fast flow high shears in one stream do so in the other stream as well, and slow water things although not exactly the same values. These scientists were answering a review that said these models were not too transferable but as some of you are probably aware that if you're doing an instream flow kind of modeling approach, there are criteria. For example, macroinvertebrate diversity, all of it, in relation to velocity, in high gradient and low gradient streams, is in some of Jim Gore's work.

The transferability question also relates to another approach when one studies the effects of flow. Not will "an animal be in this particular spot if I put my net down?" but rather "how will flow through time affect populations, survival, persistence, and colonization as population processes?" There is an expectation that these things will vary depending on the kind of stream; it is the basis for some of my colleagues insisting that the ELOHA should start with a stream classification, then divide the world into different streams, and then develop those models within those stream types. It is an idea, Mary [Davis] reported, that is being tested in WaterSMART, **the idea of context dependence (slide 36)**. How much does the observed response of fishes or mussels to changing flows depend on things like system fragmentation or whether the reach is near a larger segment, or if it's far way in the headwaters, or channel confinement, if it's a gravelly stream or not, or the water quality. How much does the context affect what a scientist can predict is going to happen as there is a change in flows? Mary responded, "So I can't answer your transferability question except to say, it is a good question."

Defensibility of ACF work in Context of Controversy (over water use)

Is this going to be defensible? What an interesting question **(slide 37).** For Mary, the best scientific understanding supports the conceptual basis for the modeling that she is doing. Many smart ecologists are involved; there are a number of reviews, even positive reviews. The underlying basis is that flow regimes, not just minimum flows, are influencing population processes via multiple mechanisms. An effort is being made to represent species persistence. Things have to be able to survive, reproduce, and they have to be able to recolonize from time to time or disperse out from there. **Moreover, that's the underlying basis for the ELOHA as well as metapopulation theory and population viability theory. So I think the conceptual basis is solid; it's very simple. There were no biotic interactions in our model**. Scientists can look at a three-day high, followed by a three-day low; they can take empirical data and ask "was there evidence that's driving anything?" Once the simulation is done, there is the ability to be very specific about the uncertainty in the projections. Down the road, there is hope that some potential applications are the analysis of alternatives in specific stream systems where the critters will be a management focus. There will be an effort to look hard at WaterSMART, at the derivation of those relations between management actions and biological outcomes in differing context. *Can we use it to derive some general expectations for differing kinds of streams and differing kinds of species?*

Facilitator: (facilitation team) reminded everyone that the EFSAB members and alternates could pose questions first and if there was time, guests could also ask questions. Let's start first with questions of clarification?

Question: Mary, you were doing these things over time in the simulation. Do you have any feedback on how long it takes for some of these differences to show up? Are we talking about a year? years? **Mary Freeman:** good question. For the mussel models, it can take a very long time for differences to show up because of modeling metapopulation. I mean that it includes concepts of the world…of a population existing in differing segments with individuals being present or absent, differing segments through time; mussels do not turn over as quickly and it might take a very long time to see differences. For mussels, we may need to model population dynamics directly – changes and abundance - to get enough data as Jim did in a five-year study. Then you can project changes in population growth rate. For the fishes, one may see something interesting happen very quickly as we did in Peterson's study of the Lower Flint. It was just a three-year study but he had two of the driest years and one of the wettest years on record, and they saw a lot of species turnover. Jim had a lot there to come back to in order to parameterize responses. Take enough water out of the stream, and you will see changes very quickly. Things may recolonize next year if there is a good downstream reservoir that holds things and allows things to swim back into the stream.

Question: It's the complexity of trying to determine on our monitoring activities that when we go out, conduct a study and reach a conclusion, that we're really looking at an acute representation as opposed to the chronic, and it seems like your work has done things over a longer time period than most of us do. I wonder if there is some guidance in there in terms of the fact of what we can expect – with a one-year study? Or with a three year study or longer? This is a big issue in monitoring where a law is written, best management practices are implemented, and measurements next year do not

yield results (and sponsors think it was a waste of money when it may actually take ten or fifteen years to see the result).

Mary Freeman: Point well taken. If we hadn't had a three-year study to start the Flint project, we would simply have the spaghetti boxes. Having at least a three-year time series to begin to estimate "what are those relations between high flow events and low flow events, and the things that happen to populations?", allowed us to get a start on it. The estimates of those effect sizes are not terribly precise. It's based on three years, so that's why we were anxious to use this WaterSMART opportunity to continue to build that database to ensure we'll have six years of data. But I agree, it's really critical. Part of our roadblock in the ELOHA, in pushing ELOHA forward, is that most folks do have one-year data , so plots are created and they are very noisy ; adding in more sites with just one year of data doesn't help. *What we probably want to know is not what's there at that point of time but how does it change. How is it responding?* Collecting data through time lets you measure dynamics, not just what you have right now. It's like if you opened my refrigerator right now, you will say, "She's going to starve." Right? But you're missing the point that there's turnover in there and so you have to open the refrigerator every day to see that turnover.

Question: Can you give us an idea of the fish data on which the model development was based? What's the timeframe for that generation of that data?

Mary Freeman: The Lower Flint study that Peterson and his students did, they went out to 28 sites, spring, summer, and winter or late fall and winter. They went out three times a year at those sites, and set up block nets in differing habitat areas and took a set of replicate pools and runs - and to the extent there are riffles in South Georgia - they did riffles. This allowed them to do two things: estimate, detection or sampling efficiency, so that if you don't get a species you don't have to assume it was absent. One can estimate a probability that it was there and you missed it. And then they actually modeled those changes through time from spring to summer to winter to the next spring. So it was three years of data, not quite 30 sites sampled seasonally with replication each time they went out within those sites. Does that help?

Question/Comment: A little bit; there was mention of previous information that Peterson had. From what you described before, it appears you all are in the validation phase of your study to see if you can transfer it, and also looking at other stream sites in slightly different habitats?

Mary Freeman: That's right. We are using this WaterSMART opportunity to collect data in a similar way but over a broader array of stream types and where we already have the hydrologic models set. We will use that data to update the model; that is we will throw more data into the pile and say, "Now, what do the relationships look like?" Validating these biological models is a tricky thing because this is where a long time series is needed. Moreover, it is tricky because of the limitations in conducting experiments on a fish population at a realistic scale. As researchers, you rely on what you observe from the field and the correlations between things. So it's correlations between "*What did the flow do last year?" or "What did the flow do this spring?" and "How many young of year did we get of these different kinds of species?" Well, the flow did many things last year and so if it were low, is it because of how low the very lows were or was it an absence of some high peaks?* There's not a basis for discriminating between those two models sometimes. One is the basis for the correlation, because of the inner correlation though as you collect more data, then you expect to see if there really is a

difference in the mechanism that you're going to start to see it. You're going to start to have some years where the flows were low but you still had some high peaks and you can say, "Well what did the young of year do then?" Does that answer your question?

Question/Comments: It does. I guess we would all love to hear that you've had the chance to go ahead and do these extensions and validations, and it worked or it doesn't work, etc., or you know what is unrealistic. I was curious to hear if you were far enough along into that process to give us a preview maybe.
Mary Freeman: I can tell you that for the Potato Creek simulation, the changes in species richness that Jim/we simulated as flows got very low and came back up, actually that is very much what it looked like based on the very few bits of data that we have. We are not seeing these simulations show us anything where you go "Oh, wow. We didn't know it did that." **There's a general truth in the models. They are based on things that we really do understand happen.** Now, whether we have the mechanisms right, we don't know, and that matters. It matters when you then ask "Okay, here's my management alternative and I'm going to affect the low flows a lot but I'm not going to affect the median flow very much," then it does matter which one you believe has the most importance, and that was the point of those two graphs of species richness when more water was removed.

Question: One more question. This is just for my clarification and your species richness estimations. Do you link the values to your observations at all or is one fish equal to a thousand in terms of quantifying species richness?
Mary Freeman: Yes; that's just a count of how many different kinds of species.
Question: So one fish equals…?
Mary Freeman: One, though you could weight them however…
Comment: Its binary basically?
Mary Freeman: Yes, it's just a count. Though you can use the data however you wanted. If one species is worth ten times as much to you as anybody else, model that one separately and then maybe look at the other data or whatever.
Comment: So I think that was just a clarification, like whether you could identify a change in the community structure. Is that something that could be modeled or is that further down the road?
Mary Freeman: So those metapopulation models are in each segment, presence/absence for every species. It would depend on how you want to quantify community structure.

Question: Like if there were shifts in abundance to a general species over fluvial specialist?
Mary Freeman: Right. The metapopulation model is not modeling abundances. The mussel model that I showed at the very end, those kinds of data could be used to model abundances but that is a different comparison since it was five years of data for one stream. Conceptually, it's the same but the data needed to model abundance across the landscape are a little bit greater. But we are doing this; I have four streams, except one of them dried up this year, where we've got several thousand marked fishes and we're trying to look at some of that internal population dynamics in relation to flow so we can compare that with what's happening with metapopulations.

Question: I have a question about Potato Creek. The demand looked like it was somewhat static, particularly for the withdrawal such that it would be 40 mgd every day of the year.
Mary Freeman: That's a good question. We did not do it that way but rather developed a realistic approach. We played with the model and said, "Does this behave the way we think it should?" There used to be a withdrawal from Potato Creek but we incorporated water use data for the City of Thomaston and looked at how is that water use distributed across the year, which seasonally. We modeled 5, 10, 20, or 40 mgd withdrawal on that with change of demands. Then the State of Georgia, for most of their withdrawals, put a 7Q10 floor, so if you hit 7Q10 you quit withdrawing, and thus we added that in. That was one of the constraints on that simulation. It wasn't in any way meant to be an analysis of how much water Thomaston could take out of Potato Creek. We just tried to do a realistic simulation to see how the model would behave.

Question/Comment: Just another thought. If we're five years down the road, you've had a chance to try the model out, to go out and observe that you're pretty much on target – have you tried plugging in different water use patterns to see if you could either reduce or exacerbate the problem and see how that responded?
Mary Freeman: That's a great idea, something we're hoping the modeling framework could be useful for - not projecting or predicting the future but playing with relative changes in relation to things you might want to try.

Question/Comment: There is a developed hydrologic classification model for North Carolina that we are evaluating right now and it does not take into account, channel morphology, nor does it take into account stream gradient. How did Peterson derive channel morphology?
Mary Freeman: They started out the project with the hypothesis of two kinds of streams. Some streams have banks that are higher than your head versus other streams that are very well connected with the flood plain and thus behave differently during low flows such that the responses of fishes to changes of flow would be different. They also sampled some of each stream over that three-year period and tested the idea of whether channel morphology was predictive of both habitat changes through time and then changes in fish density. We are doing some follow-up work in the Piedmont now with marked populations. My notion is that those very incised streams may be great places when the water's low, if they hold pools, but they may really be ugly places to be during very high flows. The sections of the streams where it is wider and flatter in a well-connected flood plain may be nice for refugia during those very wet years and not so good during dry years, so that the responses of fishes to flow might really differ between those. For example, if Fish and Wildlife were really interested in a particular species in this basin, then knowing the channel morphology might be important to inform how you think that population is going to change in response to climate change or land use change or water change. The ELOHA paper includes channel morphology as one of the classification criteria but not so many folks have gone down that road yet.
Question: Is there a remote way of sensing that? Could you do it with LiDAR?
Mary Freeman: If you had LiDAR, that'd be great. We have LiDAR for Potato Creek and so we're going back to review the channel classification using the digital elevation models since we know there's an error in that classification. We went out reviwed 30 streams or so and we said sometimes it's on, sometimes it's not, and we now have LiDAR for Potato Creek and the geomorphologists are playing

with those data. It's really hard to get at the channel incision though with anything other than good LiDAR that actually give you the middle of the stream and can actually go right down to the water level, so LiDAR of low flow would be helpful.

Question/Comment: I enjoyed your discussion of the scenario with the city of Thompson, where there was a hypothetical withdrawal. I assume in your model approach that you can look at that impact downstream and perhaps figure out how far downstream that impact might be felt,? I was wondering if you could work it the other way – if you had a withdrawal downstream, would upstream reaches in your stream network be affected by species that might move upstream?
Mary Freeman: I can certainly imagine the mechanism by which it would. That's a great question. We actually looked downstream, so that change in percent occupancy provided proof of concept. Yes, I would look upstream, especially at things where you think the downstream areas are sources or reservoirs for individuals to recolonize to the upstream areas. We have played a lot with model sensitivity and one of the things that the model is very sensitive to is how far you think the fishes move in a given year. If there's a notion out there, it's that in large river systems, if there's a recolonization, they move out from there, and then there's a different idea that species may move from one stream segment to another but most of the movements are short. Moreover, if you believe that, then your simulation shows a much slower recovery time than if you allow things to move longer from the main system out. We were asked to do some science and I think everybody on the team wanted something that would be applicable to real management questions. But what you keep coming back to are, yes, we can use the best knowledge or best understanding and kind of simulate how we think the world works and then use that to look at management alternatives, but there are still some big uncertainties there, and understanding how far things move is something we'd like to get some more information on, perhaps through genetic analysis, and we're trying to push a little bit of that. There's a lot of work to be done by a lot of folks to really improve our ability to understand and that's how things are going to change in that stream.

Question: Your flow metrics, five flow metrics, how did you select those? Did you use something *a priori*, and if so, how?
Mary Freeman: trying to remember how we selected those. You know, what we wanted to do was represent those broad flow components that Brian Richter pointed out. And then it was arbitrary. So how are you going to represent the high flow? Let's just take the ten-day max. If you had a good reason to use something else, and actually a good sensitivity analysis to do it and say, "Well let's use some other high flow metrics, take your actual observational data, look at correlations of what did fish do in relation to not the ten-day max but the three-day high flow or the peak flow or the 30-day high flow and ask how would that change your projection of how things would change under a given scenario. There is a world of model sensitivity analysis here that you could do and probably should do if you've got some good reasons to think that other metrics should be driving things, and that too is a really great question. I think it's important to, you know, from our perspective, to guard against locking onto hypotheses and saying, "This is it" because we don't really know. We know high flows matter but we do not necessarily know the best way to characterize them. So our precipitation runoff model, now that the thing's built, is easy for the modelers to say whatever flow statistic it is you want

for whatever time period. So we do them seasonally so we get a springtime 10-day max and a summer 10-day max.

Facilitator: Any other questions for clarification? How about reactions to what you heard? How Mary's presentation fits into what we are working on? Ok. Let us take a break but before doing so, please write down questions that you feel relate to the biology, the ecology. In addition, how is this going to fit into the work you're doing here? What has not been addressed or needs to be discussed further, so that we can help frame the conversation for how we move forward from here to bring the biology in.
Comment: As we break, it is possible that a lot of the points Mary touched on might come to us following the break and wondered if we could have more time with Mary.
Facilitator: Absolutely. That's really what we want to do now, is head into more discussion and certainly bring up those things that come to mind as a result of what you heard today but also anything that's been chewing on you that we need to talk about this or that we've talked about and you feel like we need to talk about more. We've got most of the rest of this meeting devoted to this discussion. So if you can write down some thoughts that you have now, then we can put those together during the break and then certainly bring anything up in the next hour or so.

Facilitator: Let's get started again. We have additional questions for Mary Freeman. Then we'll move forward with a broader conversation about how we want to work on fitting biology into the hydrologic modeling. The question we got, in talking about Potato Creek: "*Can the model incorporate seasonal changes and daily demands and then won't this alter result of change in flow?"*
Question: I have a question for Mary. It seems that a lot of the results coming from your studies and other studies within the next five years, would be really valuable in the type of discussion we're having here. However, the answers will not be at the EFSABs fingertips for time that we need to have some recommendations. With that being the case, what direction would you guide the Board in knowing that we want to incorporate ecology and ecological integrity into the recommendation that we make to Division of Water Resources?
Mary Freeman: Since my agency does not make recommendations, one way to think about this is that you do have data. Chris, Jim, and I were discussing it. There is monitoring data and you have a lot of science expertise to do the kind of exercise that we went through and say, "What do we believe about how flows affect biological outcomes, critters we care about," however you think about that based on the studies we've done. Hypothesize those. If you pull together some data, ELOHA-like, that Mary Davis was encouraging you to do, and you look for some relationships and you see a whole lot of messy noise in there but you say, "This is our best estimate of how these things change in relation to flow" and be real explicit about the uncertainty and the noise, then you're right. We all understand this. We have to go forward with making decisions. But take those models, that basis on which you derived some environmental flow ideas, or some recommendations, or however that plays out. Make some predictions about what kinds of changes you should see, recognize like Tom was pointing out that they're not going to happen in a year, and put in place some monitoring so that we can collect those data so that ten years from now you're not back with a new need for an approach and wishing that you had this data now – those temporal monitoring data that would let you look at how things actually change in relation to flow, and the other things that are going to be going on. An adaptive management paradigm is, use the best data you have, be real explicit about how you're hypothesizing

things work, show these are my data that support that idea, the alternative ideas, make the decisions you going to make, and then monitor the outcome so we can improve that through time.

Question: As a follow-up to that, if you were given a suite of modeling approaches (which I think part of our charge is to evaluate what's being done, what the state is of the current art in modeling, knowing that there's a lot of uncertainty and unanswered questions, what types of reaches… for example, *could you predict that the modeling approach you used would work better in higher order coastal streams or higher water streams or is there a particular approach?* We've focused on perhaps trying one model across the board rather than taking different approaches to different types of streams and communities. That may make the job a little harder for Jim and company in actual implementation but is there perhaps a better fit for what you're doing to a particular type of habitat area that you would advise us to follow?

Mary Freeman: Broadly, the approach we're taking is to use data sets to estimate the effects of flow dynamics on population dynamics because these are some things that we have control over – the flow – and this is what we're interested in, in its differing ways for population dynamics. So as we were just talking about, where there are monitoring data that you have temporal sequences through time, then you can begin to look at some of that and you can begin to measure it. The specific, that presence and absence kind of modeling that I showed in the simulation of Potato Creek, is probably the best fit for critters for which there is turnover (may be tough to apply to mussels), or in streams where you expect there to be some turnover, so not the main stem of a river but up in the stream network where you truly expect there to be metapopulation kinds of dynamics that you can observe. If I were focused on less of a landscape, what's happening with flows and how flows are affecting population, and more of say a main stem river, then I'm probably going to do something more like that mussel example of Jim Peterson's I showed and mark recapture or somehow estimate survival and reproduction of the population so that I can then simulate "Is the population likely to be growing or in decline as we manage water in differing ways?" and perhaps layer on that climate change.

Question: That gets to the validation point but I guess what we're faced is actually looking at what approach would be the best predictor?

Mary Freeman: To make a projection right now?

Question: And how would what you've done fit what we're faced with modeling or finding a good predictor or impact of changes in water flows in North Carolina streams?

Mary Freeman: Well, so let me back up a step. I was a part of the ELOHA brainstorming that came up with that and our concept there was whatever we come up with is going to evolve. When Leroy Poff gives a talk about it, it's hysterical because he shows all the things that people have done to the VW Bug, gluing stuff on and all that. That's kind of what we expect to happen with the ELOHA, it's an easy way to start and I understand there's already some effort there to take all those data on the biological condition that are in the file drawers and try to relate those to the biological condition at a particular location - how much the flow has been changed, or something about the flow regime there that relates to what you would manage. I anticipate it's going to look kind of like Chris Konrad's graph, that there's going to be a lot of scatter and in those situations we do these quantile regressions where you simply just fit a line to the ceiling and say, "Well it's limiting how good things can ever be."

That's what you're pulling out of that. **But my experience from the last few years of working in the ACF work has really encouraged me to keep looking at data sets, finding those data sets that will allow us to relate dynamics, relation dynamics or metapopulation dynamics to flow dynamics,**

because that is the most direct thing. Once you do that, if you've got the geography water modeling components to put together, then it's not hard to say, "Well, here are some measured rates at which metapopulation dynamics change in relation to flow. Let's simulate it," much like Jim was talking about simulating habitat dynamics in relation to flow, where you've already got the flow models. I would look at going a simulation route like that.

Question/Comment: Right now we have a hydrologic model classification and we're evaluating that but it does not include biological values, it doesn't include species presence, absence, richness or abundance or any of those features in our stream classification. Therefore, do you think that we can proceed in lieu of that, in lieu of having that community or species level type data to be modeled, or do you think that's essential? Would you guess that it would be essential for us to do? If habitat is critical, if changes in habitat are critical, and we do have habitat measures and we do have a habitat hydrologic classification, is that good enough to go forward or do we need to dig deeper into these questions about what the species' responses are?

Mary Freeman: I would think about this. I think if you have that, that's a lot. If you have a hydrologic model that probably puts differing streams and differing classes based on flow statistics. Therefore, if you had the cross section data or the basis for doing habitat simulations in some streams that are differing types and then if you have criteria…and I understand the transferability question and it's a good one. One answer to that is species that are reliably found in fast flow are reliably found in fast flow.

Comment: There's at least one feature of that community.

Mary Freeman: So you could look at things like "Well how does habitat change for these kinds of species?" I mean the only reason to have a classification system is to improve your ability to predict. So you're expecting that once you put things into classes the variability goes down. If it does not, then throw the classification out or try a different one. I mean classifications are not real. They're just a way to improve our ability to predict something. So it would certainly be a good basis and you could do it very transparently and explicitly and say, "Here's what we're assuming. Here's how we derived this and so we're predicting these kinds of changes and these changes in the species if you change the flow this much." Of course, if you stop there, then you're never going to know you're right. That's hypothesis generation part in my mind. That's the hypothesis-generation part of adaptive management; and then go collect some data whatever we decide to do. Whatever happens, collect some data that you can specifically compare back to what you thought would happen based on those models.

Question: Anybody want to respond to what our monitoring budget looks like?

Mary Freeman: I'm not allowed to monitor either and I work with the USGS. That's just where we are. If we don't get some target data collections going on out there in the landscape, whether it's done by the states, the federal agencies, or the NGO's, we're just going to keep doing this. I've been doing this a long time. "If we had some long term data results, we could do better."

Facilitator: Other questions from the Board?

Question/Comment: I'm trying to summarize for myself my assessment of the information that you presented and trying to boil it down to a fairly small piece to bite on. Here it is: that in populations

that reside in fast flowing, this at least for fishes, fast flowing reaches, not necessarily channelized streams, then the flow modeling seems to predict fairly well their responses compared to perhaps another approach that might be better used in deeper water, slower moving areas, for example, where what you've done didn't necessarily predict or wasn't the best predictor of how the populations responded. Is that a fair assessment?

Mary Freeman: The difference in what you said and what I would say is that for a species that require fast flow, their habitat associations are predictable so that species that go in this river, a fast swift flowing areas, that's where they are; if you go to another river, they'll be there again. But that's a little different than predicting how their populations may respond. So for example, lots of fishes start out their lives over in the margins around the water willow and stuff. The minnows, young of year, and darters, they're very small, they're looking for the refugia from flow, and how the population responds in over the years may have to do with flow dynamics in those particular habits. So starting with a specific hypotheses of here's how we believe flow is affecting things, would give you some guidance in picking those out. In terms of transferring criteria, that is if I go to several different streams, those criteria will be good predictors of where I find the animals. Then one group that tends to work better for than other groups are those fast-flowing 'I love the flow' animals. Lots of minnows, for example, also love the flow, *or* they can go sit in an eddy and pick stuff up out of the eddy. That's a good place to feed too. *Or* they can go over someplace else and feed off the bottom. So where you observe them in differing rivers may really be dependent on how is that pool shaped and are there big eddies.

We've quantified some of those changes and that's why I think those kinds of criteria may fit more poorly for those because you just can't predict on the basis just from depth and velocity where they're going to be. But it's a little bit different question than the "And how will the population respond?" Back in the late 80s or so, ecologists really started picking hard on the response approach because they said, "You're using habitat as a surrogate for population response but maybe the habitat thing that you're modeling isn't what's limiting the populations. *How do you know that it is?" and so it comes back to needing more validation data in those cases.* Mussels are notoriously hard to model habitat for, as we've discussed. Their habitat limits them as opposed to a fish that can move around and track kind of quickly and stay in a good spot. Mussels have to more or less sit and take it. I mean they'll move a little bit. So how flow dynamics affect juvenile settlement and then their ability to then grow and then make connection with host fish to reproduce, all of those things, and it's different than how we generally think about modeling habitat for fishes. So the difference there is thinking about flows and then making assumptions about habitat being the thing that affects your population ability able to stay there through time and going directly from "Well how does flow actually affect the ability of your populations to stay there through time?" Habitat simulation is not a bad way to go, and for many animals it's going to make a lot of sense and for others it won't be so helpful and that's all I'm trying to say.

Question (webinar): It seems that the essential part of the analysis and the results are the relationship between flow or surrogate measures and probability of extinction. How were the basic variable relationships developed in your professional judgment?

Mary Freeman: Great question. It is not based on professional judgment but rather on the data set. The model that we're using right now, this was modeling Jim Peterson did. It's regression modeling between

using an empirical data set that is a set of measurements of about 35 or 40 species of fish, present/absent, from one time to the next, over a set of 27 differing stream segments. So this was a direct observation, and extinction, and we should be using local extirpation. It does not go away forever and ever. That is, the animal goes locally extinct in that one segment but may recolonize itself a different time period. What we're looking at is the dynamics that are running the simulation for example, if the stream dries up, and all of the fishes go extinct locally and then they have to recolonize at a different time period. The opposite of going locally extinct is persisting – staying there and reproducing.

Facilitator: Thank you. I think we're ready to move into the broader discussion of things.

Discussion About the Biological Aspects of Eco-Flows

Facilitator: It's come up a couple of times today for you to think about what questions you all need to discuss about biology; you've brought forth several questions. What other questions come to your mind after listening to this presentation, going on your break, and thinking about it?
Comment: Well, I don't know if this is really a question or thinking out loud or an observation. I mean it kind of points out the two tracks that keep coming up repeatedly – the blue boxes and the green boxes, if we go back several meetings. One being a habitat-based approach to try to get the ecological response to changes in flow, which is all the various bar charts we've looked at, and we'll probably look at some more when we have more sites incorporated into them. The other is actually trying to see if there are correlations between the biological data and some degree of flow alteration, along the lines maybe of what Mary Davis described that they did up at the Potomac Watershed. Each has its pitfalls.

There is the transferability issue. What Mary had to say today I think was helpful, in terms of at least for those riffle dwellers, fluvial specialists, we maybe had a little better comfort in terms of extrapolations from one site to another or one site to other unmodeled sites, but maybe have some more question marks for those that are not the fluvial specialists. The flip side is when we go down the biological data track, we have all the noise that can be built in, particularly since in most cases, if not all cases, the data wasn't collected with this particular use in mind, in terms of where the data was collected and how often and so on. There is no real answer to that but I just kind of wanted to summarize where I see us sitting right now. A couple of things that came to mind from what Mary was saying are: 1) maybe from a habitat base we can look more closely at the riffle dwellers and how they respond to changes in flow; and 2) in classification do we need to incorporate channel morphology, incision, and slope? I am also thinking about a couple of the studies she put up there in her slides. One had to do with stream size and the size of withdrawal and the ecological response. There was a much larger relationship in the smaller streams than there was in the larger ones, so maybe stream size might come into play in terms of how we classify streams. And it does already, since ours is hydrologic statistic based. I'll stop there. I'm throwing things out there. Maybe other folks have responses to that or have their own thoughts on what we've heard today.

Comment: I tend to agree that as we try to merge the ecology with the hydrology that there's a risk of oversimplification, but certainly when you have a lot of varied reactions to changes in flow by

whatever measure, it may be that for this exercise that we've embarked on for the past year or more and expect to be at for the next year or more that we should really focus on those most sensitive species and interactions and that if we could pick out things like those riffle dwellers that that's the way to go. Stay away from generalist and go right straight for the jugular and get at those species that are most profoundly affected by changes in flow, as those changes can be affected by whatever management action we're seeking to get after.

Comment: I also think there's a critical point in some of the stuff that Mary presented, and that's in terms of looking at the populations and processes in terms of persistence that we're not addressing with the classification model that we're dealing with now, and we need to be aware of what we're really charged with is ensuring that these populations are persisting over time and whether this group is recommending methods that will ensure that that occurs and whether the methods we're looking at are going to assess whether these reproduction and colonization processes are still sustainable. I'm not saying we don't do that, but we need to provide guidance, I think, for the long term as to "Here is where we are today. Here is what we need to have. Here is where we need to be in 10 years." One other observation I'll make. I just thought about it. In the beginning Mary talked about how they broke it down to, I think, large floods, small floods, flood pulses, extremely low and base flow, and what struck me there is that our realm, the way I see it anyway for this Board and my division's work here is we're going to be focusing most on the base flows and extremely low flows since we're looking at the effects of withdrawals, which are going to be most felt at the base flow and extremely low flow and not at the flood flow end. The models we're plugging these into are built… aren't flood models either and we're not looking at "is there a different way we should be managing flood control reservoirs for storm water retention ponds" and things like that. So in some ways I think that might simplify our work a little bit if we can try to focus in…if we're focusing in on the riffle specialist and if we're focusing in most on the effects at the base and extremely low flow end or from the median end down, than what happens at high flow. It's not that high flows aren't important; but that's not what we're really looking at.

Comment: But if your withdrawal dampens the high flow in a way that actually has population implications, then it could skew your interpretation of your low flow, if you're just focusing on controlling withdrawal at low flow. If it has a dampening effect on the high flows and that is actually the mechanism, then you're going to misinterpret your results if we ever did monitoring.
Response: It would have to be a really big withdrawal to be able to do that. And the thing is, if it was a big withdrawal, it would be on a stream with a really high flood flow because people that use water at that scale don't go to a little stream and have a really big withdrawal. They won't have enough water there in terms of how we interpret the monitoring data. Because if we're downstream on a stream that happens to be associated with a reservoir, irrespective of how much water they take out of that puddle or not, the presence of the reservoir will dampen the flood flows and that could be affecting your ecological data. We have to be careful how we interpret that.

Facilitator: I guess some of the challenges of continuing this discussion is how do you want to address some of these outstanding questions? From the facilitator's standpoint, I can try and tell you what I'm hearing and try to connect us back to last month's presentation and discussion as well. You're looking

at your habitat suitability curves and how you can apply those most accurately or tweak them. Last month you talked about how can you make those better, right? Or there are completely different methods, that you're hearing about?

Comment: I think there is a connection between the two and it goes back to that classification scheme that's been out there now for going on two years and has not been evaluated in either context. I think we really need to look at what does this group need to have in order to evaluate that classification and determine whether it meets the needs of the ecological flows, or if it's useful for that, or whether it needs to be modified. I think the things we need to look at are: 1) what are the habitat characteristics associated with each of those classes; 2) what are the biological characteristics associated with those classes; 3) what are the responses that you get out of the PHabSim. We need to look at those as Mary said and see if they are reducing the variability. If the variability for those things within those groups is as large as or larger than the variability among groups, then it's useless and it needs to be modified. If the variability is less than those groups, then it's working. But we're now almost over a year into this process and we haven't even made that basic investigation yet. So I think regardless of which direction we go, we still have to address that at this time, I think, before we can make any meaningful progress.

Question: What's the process for us to get there--the models' results that Jim is presenting? I mean can that be evaluated for variability by classification?

Response: Yes, I think so but you need it for a large number of sites within and across classifications. Well a large number would be within before we could even begin to look at it. It may be perfect. We do not know.

Question: But we're pretty far away from getting to that point, aren't we, as far as having the data to analyze for comparability within a classification and then between classifications?

Response: Yes. That's partly a function of just the time involved to do it, and partly we need the OASIS Models or the base models. We don't have any in the western part of the state right now and that's where most of our study sites for those small, medium, and large stable streams fall, are in those basins.

Question: Jim, are there enough data points available if someone had the time to do it, or is it just a lack of… Assuming the OASIS models could be developed first, are there enough data points available so that we can estimate those in-class versus among classes variances?

Response: I think there's enough to give us a good feel for it, with the exception of coastal and possibly the seasonal streams. We just have not had a reason to do much work on either of those types. We've got quite a bit of diversity from the piedmont/west. I don't have them here in my hands but a meeting or two ago I distributed a list of the sites we have by classification. It's not a huge data set but it's more than a couple in each. There's typically anywhere from six to a dozen in each classification, with the exception of coastal and the seasonal.

Comment: I am concerned that we are really constrained by the amount of time that it's going to take to process that data. We have ongoing modeling that DWR is continuing to use to model for Cape Fear and the Neuse, and withdrawals will be evaluated using those models and into the future. Is that accurate?

Comment: I'm trying not to jump into Tom Reeder's presentation, but those models are hydrologically completed or in the process of being completed, but all they have in them for ecological flows is a placeholder, so our ability to use them to look into the future and say whether all needs are going to be met, offstream and instream, is not there.
Comment: That being said, I have sort of been percolating all this over the holiday and I feel like we need to, as a group, agree to a couple of basic features that the ultimate prescription will have in it. I think people maybe actually have consensus on this but we never attempted to evaluate consensus on some of these aspects: 1) a natural flow regime would be what we're after; something that would allow withdrawals but within a natural flow regime that we would be mimicking; could we come to a consensus that in order to maintain ecological integrity, flow needs to be as close to natural as possible? 2) whatever our proposal is, it needs to be adaptive, that going into the future we would try to incorporate some type of monitoring activities or incorporate other aspects, other agencies, monitoring data to be evaluated so that the process could be adapted if we are in fact wrong with whatever our recommendations might be. So if we go with fluvial specialist and impacts are predicted, for example, but that doesn't actually protect ecological integrity, however that might be evaluated, we would be able to go back in and reevaluate and adapt the recommendation; 3) a recommendation to go ahead and decide on a presumptive measure that could be incorporated as soon as possible into DWR's methodology so that that placeholder has a real number in it even if we hope it becomes a more specific number as this group continues to meet.

Question: Are you proposing a presumptive standard? Is that Number 3?
Response: Yes. I would say we need to stop what we are doing to at least continue the evaluations on the hydrologic classification in the background but that the group decide or hold a discussion about what an appropriate presumptive measure would be so that DWR can start using it.
Comment: I would not be comfortable with a presumptive standard.
Response: Just one response from me. As much as I like the idea of having the natural flow regime as the target flow regime, our legislation restricts us to conserving. The way the law is framed, it ends up being essentially an anti-ecological degradation strategy rather than a shoot for the moon and restore all we may to natural conditions standard. I'm not thrilled that it's that way but it is that way.
Response: So if that's the case, we would still want in our prescription to state that that would be the intent, that it would mimic the current condition rather than a natural condition. Instead of the flat line or some of the alternatives that exist.
Comment: I think that we are shooting for a pattern of flows that will continue to sustain the critters and processes that are in the stream now and that we'll maintain the stream as a viable entity or as a viable ecosystem. I think we are constrained to that. That's actually not bad. It's not as bad as it could be. It's definitely not a matter of us setting some sort of minimum flow that has to be left in the stream or some other sort of flat line strategy. We do get to defend as well as we may a pattern of flows in the stream in the context of withdrawals.
Response: How exactly do we communicate that to Division of Water Resources? What's our methodology for communicating? It does seem like we're missing a key process where we write down what we mean and send it towards the powers that be.

Comment: I don't want to speak for DWR, but when I talk with those guys they seem to be totally on board with the idea that we're going to protect a pattern of flows in a river in order to maintain as well as we may its ecological integrity.

Question: Have we ever established that that is the consensus among the group?
Question: It's in the law, isn't it?
Question: Are we all reading and focusing on the same words in that law? I'm just recalling that the charge before us was first to characterize and there are ways of characterizing flow, especially when we look at regulated systems or those that are already altered, and that's the chief characterization: is this already an altered system? This doesn't have a natural hydrograph. It's regulated or abstracted. I'm just getting back to that antecedent part of the definition.
Comment: I'm looking at it but not finding a place where we disagree actually.

Facilitator: I think what I'm hearing from Judy more generally is we need a more defined process for making recommendations and for bringing up matters to determine where there is consensus.

Comment: Let me describe two processes and see what you think. I am hearing that the ELOHA process as it has been written up in the literature of identifying classes, identifying flow requirements for classes and then moving on from there is somewhat okay with folks. I'm also hearing that there is considerable discomfort with the fact that our classes are purely hydrological classes, and I think there are two alternatives to fixing that discomfort. One alternative is to start over and develop a set of habitat classes or ecological classes and I haven't the slightest idea how to go about doing that. The other possibility on which I've begun to do some exploratory work is the possibility of testing the classes we have for biological fidelity, the extent to which the organisms tend to cluster in the classes, using Heritage data, Wildlife Resources data and DWR data, and basically just see if organisms are clustering in the classes. I don't know if they will or not.

What I predict is that there will be multiple clusters of organisms for each of our classes, depending on some other topographic variables, and that we may then, because of this investigation, want to subset the classes according to these multiple clouds of organisms that are showing fidelity to the classes. So that's a strategy for how we can incorporate biology into the process. But taking that tack doesn't do anything but give us classes that have more biological integrity. It doesn't create classes that are based on ecological variables. Personally, I'm fond of the idea of having classes that are based principally or exclusively on hydrology and topographic variables because then, in my mind, class is the independent variable and the biological responses are the dependent variable. Then when you take water out of the river you're messing with the independent variable and you're looking for a response in the dependent variable. When you take water out of a river you're altering its hydrological characteristics. That's why I'm comfortable with that strategy, but if the Scientific Advisory Board is for the most part not comfortable with that strategy, we've got to work with coming up with a set of classes that are based on ecological variables instead.
Comment: If you use the example that you just gave about the animals being the ecological response, we still have to decide which animals, what group of animals. Many connections don't exist right now.
Response: I don't know the answer to that. It seems to me that certain organisms or guilds might turn out to be more canary-like than others. Some might turn out to be more sensitive to modification of

the variables that define the class than others. If that's true, then we ought to be figuring out what they are and which ones they are and what the limitations are for them to persist. I don't really have any alternative strategies. It seems to me that the indicator species or guilds might be the next best step after coming up with a set of classes for which we can identify a high level fidelity.

Comment: Sam presented a start to try to match up some biological fidelity to the hydrologic classes that we have so far. There is some other work going on right now, some by Mary Davis, doing work for the South Atlantic LCC. She's trying to expand that more broadly to the entire Southeast to look at classification not just from the hydrologic perspective but using a couple of different classification schemes – using the same general approach that Jim Henrickson did, the hydrologic classifications that we did in North Carolina. Ryan McManamay who was a Ph.D. student at Virginia Tech did that more broadly for about five states in the Southeast. Chris Konrad, who Mary Freeman mentioned during her presentation, is doing a different classification that's not published yet but that's going to be another thing that Mary Davis's work is going to try to use. Then there are more general classification systems such as the one that Arlene Olivero did in the Northeast. So in the next several months Mary Davis's work is going to try to get at some answers there for the Southeast, and more broadly than that even, to which of those classifications might be useful, then again beyond that, to Sam's point about the biological fidelity question, another component of that work. I don't think we have to start over. I think we've got an opportunity to tap into what someone else is going to be doing and finishing up to help inform our process here.

Comment: McManamay's classes were derived independently from the EFS classes using a different suite of variables, but they map one for one on ours in North Carolina where there's an overlap. McManamay didn't get into the Coastal Plain, right?

Response: No, he actually did have a black water class but there was high overlap, that's true.

Comment: And the Konrad classification includes topographic variables, which I think is excellent. I'm really looking forward to seeing it. I am now persuaded that a pure hydrological classification or pure flow base classification that does not include topographic variables is inadequate, and I think what we need to do is figure out a way to incorporate them. Going with the Northeast strategy basically means starting over because we would have to use that methodology in an entirely different part of the world.

Comment: Part of Mary Davis's work is trying to see if that will extend into our neck of the woods. That Northeast classification went as far down as Virginia. It's not like we're trying to apply it to Mississippi.

Comment: If she brings the New England classification South, she's doing that with SALCC money?

Comment: She's trying to use multiple pots of money, but the bulk of it is SALCC, which includes the eastern two-thirds of North Carolina.

Question: When can she get the Southeast done?

Response: I think she's supposed to have a product for some of her money later the first half of this year, but I need to talk about that with her for another reason as well. The other thing is the Appalachian LCC has some money. Ecological flows science need was in the top five science needs identified in a recent workshop late last year, and so there's going be some additional effort and money put forward from the Appalachian LCC, which covers the other third of North Carolina. I see these other efforts and the other work that's going to be done as helping us out; it doesn't give us something right now that we can chew on, but I think it will help inform us as we move forward.

Facilitator: Jim, was there another study that we're talking about for testing fidelity to stream classes?
Response: Sam alluded to it.
Facilitator: Okay. Do you all have any thoughts about moving forward, dealing with the stream classes? Tom, I guess I'll bring it to you first since you brought it up -what are your thoughts?
Comment: I'm not sure I have thoughts anymore. We're a year into this process and now we're about to drop everything and go with…I mean there is an infinite number of classifications. That's one of the attributes of classes. You can put as many classes out there as you have sites going into your classification. **The point, I think, that is important is what is a classification going to be used for?** I think eventually, and Jim needs to answer this one, but I think it's because they're going to be applying the same type of criteria to sites and have it following the same type of class, so that instead of dealing with a thousand sites across the state that they have to deal with individually, they'll do it with "this falls within this class, therefore we have these expectations". We simply have to pull all that together into a classification that meets their needs.
Response: Yes.
Comment: But right now we have a classification that money was spent on that we have not even looked at yet and it is a little frustrating to think that we are going to throw it all out now without looking at it.
Response: Define looking at it.
Response: That is what I think we need to talk about. What does this group need in terms of evidence to buy into this as a classification procedure? For me, I would ask for things like: What do we have in terms of the channel geomorphology within these different classes so we know how variable they are? We have information on natural hydrology in there; what's the biology look like? Not in terms of just species but we also need to look at guilds because the species may be varied but they may be functionally the same. We need to look at other response to the system which I think is valuable information to have; it may not be the only thing. We need to look at what habitat suitability curves are available. Are we using the same curve everywhere? This is the type of information I think group needs to look at in order to decide whether this is a good starting place, whether groups need to be combined, divided, or whether we need to pull in information from other people's classification systems. I don't think at this point we should abandon where we are without first examining where we are.

Question: Tell me about habitat suitability curves. Habitat suitability curves are typically drawn for guilds, not for classes of stream, right?
Response: If you're using the same curve everywhere, then it becomes a constant and you can throw it out because it's not providing you anything. In other words, if you're using the same habitat suitability curves everywhere…
Question: But if you had a habitat suitability curve that related a guild or a species class and it was not being used for other classes. Would you be comfortable with that?
Response: I want to know if that's what we have. Right now I don't know what we have to back up these classifications. It's just a matter of trying to assemble all the information we have: Here is a class, here is all the information we got, and now we can go look at these things and can make

discussions about "We don't have the information we need. We need to find this. We need to go talk to somebody else." Right now we're just kind of flailing.

Comment: I want to make a couple of quick observations, but then the other thing I was going to just ask the Board, if they think it might be a good point in our discussion to have Tom Reader step in and give a sense of what the Board has done and what the Board has left to do and that might help us inform our discussion going forward. I wanted to respond to a couple of comments I heard, and that was: In terms of the classification, there are some efforts underway. We're not really ready to discuss them today but maybe when we talk about the agenda for the next meeting we can. In terms of how we're going to take another look at the hydrologic classification, I would just remind folks – I think it was the November Meeting, Steve Reed's presentation – that we need to be able to do this at lots of places where we will not have any on-the-ground data other than what flows the Oasis Model produces and that was one reason we initially went with they hydrologic classification approach. We don't have the luxury of being able to run around to every place we need to know what the class is, although from what Mary said, there could be some advantages to having things like channel condition or gradient and I'm kind of torn on that. Yes, they might be useful information but realistically can we gather that for our modeling and planning purposes? And with regards to the habitat suitability, I was just going to observe that so far and to a large degree we're going to use the same ones at all the sites. But I would note that…I think Chris put it this way a meeting or two ago, I think it helps if we think about them as not so much what happens to this species but how does the physical conditions in the stream change in response to a change in flow? We have multiple indexes of how those conditions change, which just so happen to correlate to the fish that use shallow/fast habitat or shallow/slow habitat or deep/slow or deep/fast. Yeah, this species might have a little bit different preference in this river than it does in that river, but if we use the same index scale for multiple streams, our hope there is we get a relationship curve in terms of how do the physical conditions in the stream change with varying degrees of flow change?

Comment: Picking up on what Jim said, we're grasping with what model is the best, what variables we need. We could stay in here for the next 10 years and grapple with this problem. I don't want to oversimplify it. We need to be aware of that. But I'm just wondering if we need to revisit what Jim was hitting on with the percentiles of 20% and 80% and go back to that and look at that and revisit where we were headed with that. I'll just throw that out in terms of my thoughts. Another thought is, whatever we come up with it has to be defensible. It's got to stand up to legal challenge and that's where when I hear presumptive standards, that makes me real nervous because if you start throwing out numbers that are presumptive, that opens up for challenge. I'm not comfortable going there but I do like where Jim was headed with that approach using some instream flow data with the index 120 and 80 percentiles or something similar to that percent and going back and revisiting that approach.

Response: I mentioned that because I feel like it's a way for DWR to not necessarily make decisions based on that presumptive standard but that it would allow them to see just within the next couple of weeks or next couple of months, as these [river basin models] are being used, to at least give us an idea of where the allocation stands now; we just don't know in any given stream where our allocations are relative to any kind of ecological integrity. That would be the advantage. Given we obviously have a lot of work left to do, they could make evaluations without any restrictions but just make an evaluation, and we could continue our work knowing the ecological aspect would at least be taken

into consideration. One question I have about the hydrologic classifications is if we're looking at a stream network, do we know how the classifications would actually fall out in a given stream network where you're trying to make the decisions? Do we have A, B, C, D; A, B, C, D patterns? How often do we see a shift in classifications within a given stream network? Because, to me, if it happens a lot, then utility is questionable. Maybe I'm just misunderstanding something fundamental.
Response: No you're not. That's something we're grappling with. Right now, basically, it gives you A-G at whatever point you plug in that flow. What you're asking for is something we're interested in developing, and that is a color-coded map where you would represent it so you can see "Does this stream maintain its classification to some point and then change to something else?" and so on. Part of that is just a matter of trying to figure out how best to model it.

Question: You would have to simulate a bazillion gauges to do that, right?
Response: Well, at some interval so that you could say if it's A here and A here, it's between the two. But if it goes from A to B, at what point does it change?
Comment: The critical part about that is the biological fidelity that we're discussing proceeding with because biological fidelity potentially does not change as quickly as a stream classification might.
Comment: Perhaps we need fewer classes or we can figure how to pair up to the biological data.

Question: Have you considered a rating system and instead of going alphabetical go numerical?
Response: We have considered getting away from a narrative description because we kind of get caught up in calling them small flashy or coastal and then when they don't happen to line up geographically we have concerns with that. Whether it's A-G or 1-10 or 1-6 or whatever, I think that is a good way to go. What we want is a series of buckets, whether it's one bucket for the whole state or three for Coastal, Piedmont, or Mountains or 15. But when we've got a withdrawal happening on Stream X, which bucket does it go in? Depending on which bucket it falls in, there's some Rube Goldberg contraption that cranks through and says, "There's the ecological flow for that bucket." This bucket's got a different set of gears and wheels to crank out a number and that's the way it's going to fit in the model.

Question: Wouldn't that concern you if between Point A and Point B there is a significant change in classification, change in prescription so that presumably Chapel Hill would have a different prescription than a system that's just 25 miles downriver or less?
Response: It would depend on the drainage area and I would think since flows are so closely correlated to drainage area, regardless of flow statistic, that that gets built into your hydrologic classification. Now if it's 20 miles down the road but it's because the creek ran into Jordan Lake and now you've got the Cape Fear River instead of this small stream, then that doesn't concern me because there's a reason the classification and ecology is changed. You would hope that while you're still up there, and they're all fairly small streams, there wouldn't be changes. But we haven't looked at that. I'm going to go back to the comment I made 5-10 minutes ago and I think some of the questions that are coming up might be further informed by hearing from the DWR midcourse evaluation, in terms of where we are or what we have less to do, pros and cons of what we have done so far, and I also want to make sure we have enough time to get that in before we adjourn.
Comment: I concur. I'd like to hear from Tom.
Facilitator: We'll bring Tom up here and then we'll come back to this conversation when he's done.

Mid-Course Assessment: Tom Reeder

I'm Tom Reeder, I'm the Director of the Division of Water Resources and more or less when they passed the session law, DWR was tasked to orchestrate this Board. I'm not a biologist and I'm certainly not an aquatic toxicologist so I can't judge the scientific value of your work in any way, shape, or capacity but what I can inform you about is kind of where you stand in terms of executing the political mandate that we were given to figure out ecological flows for North Carolina. In fact, I was just asked to give a presentation of the work of this board to the General Assembly. I guess it was last month I gave it to the Environmental Review Commission of the General Assembly, and they are extremely interested in the progress of this board and what is going on over here. They asked many questions. I tried to fill them in as to what we are doing, what you all are doing, and where we're headed. They seemed quite pleased with everything. One thing I will add is that, again at my presentation, I offered to procure a copy of that textbook, the reference book that we got everybody on the Board, for any member of the General Assembly, any member of the ERC that was interested in reading more about it in their spare time. I actually got seven members that requested a copy of the book, so that shows that they do indeed have a valid interest in what's going on over here. One thing I want to do is remind everybody that what we're trying to accomplish here is really quite unique. I think you need to keep that in mind when you're going through your deliberations here.

A lot of states have attempted to do what we're doing right now, but they gave up. I know South Carolina did that. They formed a board to look at some of these issues, and they gave up. The reason for the genesis of this board, at the beginning anyway, was because the General Assembly and the advisors of the General Assembly looked around at some of the standards some of the other states had adopted and they didn't like any of them. None of them were a good fit. Obviously, we don't want to follow the example of Alabama and say, "Well let's just use a 7Q10" or something like that, or what they did in South Carolina or Georgia or any of those other places. They just looked at all those things and said, "Well we don't like any of these so we think we should start over and do it right and come to a valid scientific conclusion of what the ecological flow should be."

So I think it's very important to remember what you're trying to do here really, in my mind, hasn't been done anywhere yet, in terms of just looking at the site and coming up with a purely scientific non-political answer to what the ecological flow should be for the water bodies of North Carolina. I guess the reason I say that is because I know you are probably frustrated sometimes with the progress of the group and things like that. But it's a very difficult row you're trying to hoe down here, so that's why you're running into some of those roadblocks. I think it's important to keep that in mind, that what you're trying to accomplish really hasn't been accomplished by anyone yet, and so if you could accomplish it you would be the first to do it. You really have a unique challenge ahead of you here and I certainly appreciate your efforts in trying to accomplish that, and I know the General Assembly does also.

I hear a lot of talk about timeline and urgency and things like that. Remember, there was no mandate in the original legislation for how long this board could meet. They just said meet and when you have an answer, let us know what that is. When I spoke with the GA last month, they asked me how much longer I thought it

would be before I could come back to them with a really good idea of what ecological flow should be in NC. What I told them is that I thought the SAB might need to meet for another two years – this was in December 2011. I said I thought the SAB might need to meet anywhere from one to two years and then after that it would probably take DWR a year to digest that information and kind of come up with some idea of where we really stood in NC in terms of ecological flow. **I told them I wouldn't expect any definitive answer in terms of ecological flows in NC until maybe three years from now and they were fine with that.** They didn't say that's way too long or we need to speed that up. They were absolutely fine with that. I just want to say that to you so people don't think we're under the gun and we have to get something done in the next six months, next nine months, something like that. Not to my knowledge. Nobody is pushing me to get it done in any kind of timeline so I wanted to make you aware of that.

Also, I know there's a lot of concern about "Well DWR is cranking out these models but they don't have ecological flows in them." Well, that's true but we have a placeholder for ecological flows in them. You have to remember, the timeline that these cities are looking out into the future is 20-30 years in the future. We could be wrong but we have a general feeling that right now what we're doing in North Carolina in 2011-2012, hopefully, I don't think is significantly impacting the ecology on the state. I could be wrong on that. You all might think I'm wrong, but that's our general feeling right now. So we're okay today. Cities, communities, the planning organizations in the state are looking out 20-30 years in the future so what I'm saying is that the models assist them in looking out 20-30 years in the future. **My point is I don't think it's that critical whether we have the ecological flow piece in place in the model 18 months from now or 36 months from now when you're looking out 20, 30 years into the future.** Again, that's just my personal opinion. I've talked to some of the staff at DWR about that opinion and they kind of agree with me, so I think, again, that kind of belays this idea you're under some kind of urgency. Maybe you are sick of meeting and there's some urgency associated with that, but I can't speak to that. I can only speak to the political urgency to the situation and to my mind there isn't a lot right now on you; there's not a lot of pressure in that respect.

One other thing is we have a presumptive standard in DWR that we use today. We say that if any project is going to use more than 20% of the 7Q10 they have to do a site specific study before we'll sign off in their EA or EIS or what have you. So that is a presumptive standard, and I feel that is a very, very conservative presumptive standard. Twenty percent of the 7Q10 is not a lot of water. I don't want you all to have the feeling that people are just sucking water out of the ground with no regard to the ecology because they do have to go through the SEPA or NEPA process. We do look at that and if they are going withdraw more than 20% of the 7Q10, we do require some sort of site specific study so we have that also going on to try to **prevent any kind of degradation to the ecology** while you all are in your deliberations. I wanted to make you aware of that also. I think certainly there are reasons to get this done. A lot of people want to know where we stand and where we stand in the future. I know there are a lot of people in the General Assembly that would like to know that. **But again, the emphasis is on trying to do something right, trying to do something that's scientifically defensible**. I think I heard you say that, John. And really, trying to do something that no other state – certainly no other state in the Southeast – has been able to accomplish yet. So that's kind of what this board is all about and everybody recognizes that fact, I think.

You know, you all have made some really good contributions in the year that you have been meeting. **My understanding is that you gave a lot of really strong critique and suggestions about our initial stream classification system that was done by the folks in Colorado (EFS) and that because of that we're going back and redoing that and making it a lot better. So that's something really positive that I think has come out of the process so far.** I guess you also have developed **these two parallel paths you're looking at going down now, which is a habitat-based approach and a biological response flow alteration.** To my mind, just that much work being accomplished in a year is pretty good. We've gotten improvement of our stream classification system, and we've gotten two parallel paths that we can go down to look and see if we can come up with a true ecological flows methodology for North Carolina. **I think that's a fair amount of work you all have accomplished in the last year or so.** We're going to revise and finalize the classification system for North Carolina. We're doing something called fidelity testing and once that's completed we'll have a much better classification system than what we had going into this process and then we're going to look and see which one of these paths is the best for North Carolina --the biological response model or the habitat response model. That's a lot more than a lot of other states have accomplished, and I think once we determine which model we want to use, then the matter comes down to determining the threshold of change, that means that the ecological flow is being degraded and we have to take some sort of action. To me, that is kind of a roadmap of where we can go with this whole thing, and if we can accomplish those things I think we would have an extremely good system for North Carolina. But again, that's just coming from me and I'm not a biologist, I'm not a toxicologist. In my mind, if we could get those things done that would be an extremely positive thing for the state and something we could certainly take back to the General Assembly, something we could put into our model and something I think would give us a very good idea about planning for the future without impacting the ecology of North Carolina's rivers and streams. If anybody's got any questions for me, I'd be happy to answer them, based on my presentation to the General Assembly or something like that. Thank you very much for what you're doing. I know my superiors in the department certainly appreciate it, and I know the General Assembly appreciates it because they've both told me so. They recognize and appreciate the work that you're doing. Thank you.

Discussion/Questions/Comments for Tom Reeder:

Facilitator: I think Mark has a comment.

Question: Thank you for the encouraging words and that certainly makes us feel a little better. But I guess I'm still struck with the question and for you, when you go to the General Assembly (GA) again and report back in a couple of years, are we all going in the same direction? Do we all fully expect that when you get to the GA you're going to tell them that there is a volume of water in any stream or in every stream across this state at which the ecological integrity of that stream could be impacted adversely if there was a water withdrawal or extraction, and is that level of water withdrawal somewhere above zero?

Response: What I would hope to be able to tell the GA, in say three years time, is that we've come up with this ecological flow methodology that would allow us to put some sort of process or post-processing assessment into our models that would allow us to determine if the projected uses of the rivers and streams in NC, for the ones that we model, for the basins we model, would have a negative impact on the aquatic ecology. For instance, we know what the projected uses for the Cape Fear River are, and we know that we have a model done. We know what we can project the usage out fifty

years. So I could go to them and say, "If these uses occur…" in fact I could say to them, "The uses that we expect to see in the Cape Fear River twenty years from now will have a negative impact on the aquatic ecology of the Cape Fear River. What do you want us to do about it?" That's what I'll say to the GA. And for every model that we have done by then…in fact, we expect to have almost all the major river basins in North Carolina modeled by the end of year 2014, so theoretically by the time this Board gets done and we have a chance to digest this information, I could go back and talk to them about every major river basin in North Carolina and about whether we think that those projected uses of that basin are going to have a negative impact on the aquatic ecology.

Question: Given what we've heard about the need for monitoring and adaptive management and given the current state of the economy, do you think it's realistic that the Legislature will support the monitoring work necessary to ensure that whatever this group puts together and the state adopts, that the monitoring is put together and that it's working?
Response: Well, I don't know. I can't read their minds. I don't know what they're thinking. Again, that's beyond my purview. I just focus on my job. When I approach every task trying to complete my job to the letter of what I'm required to do, my job is to come back to them with an ecological flow methodology from North Carolina and insert that into the models and tell them whether the projected uses are going to have a negative impact on the ecology or not. What they do with that after that point in time I could not tell you. That's beyond my scope.

Question: When you addressed us before, you said you viewed the role of this board as providing scientific input for the stakeholder process. How do you foresee that process moving forward in this?
Response: We had a slide that Jim got from someplace in VA where they went through the same process. What I told the GA is that probably someday they're going to have to initiate another stakeholder group that will have to figure out how to implement a policy that comes out of the scientific process. I told them this is purely a scientific process and that we're not making policy for North Carolina in this board. What we're making is science that will determine if projected uses of our river basins are going to have a negative impact on the aquatic ecology. What they do with that information, and how they react to that information as policy is, my feeling is, they're going to have to have a separate group to determine what that policy should be. In fact, I actually used an example with them. I said, "Let's take the Town of Louisburg; they have an intake on the Tar River." I said, "Let's say our models show that Louisburg's projected use of the Tar River 20 years from now is going to have a negative impact on the Tar River." I said, "Somebody, it's not me, is going to have to decide what we do about that. We've got options. Do we tell Louisburg they can't do it? Do we tell Louisburg they can do it? Or do we tell them they can only do it with some sort of mitigation factor?" But that's a policy decision and that's not the decision of this group here. That's the decision that's going to be made after you all figure out whether that use in 20 years is going to have a negative impact on the ecology or not.
Facilitator: Is there anybody else that has questions while we have Tom here? (Question raised on funding):
Tom Reeder: If money is needed, the EFSAB can make a budget request. Thank you very much. I really appreciate what you're doing.

Planning for the Feb 21 Agenda

Facilitator: We have a couple of things to cover in order to develop the Feb 21 agenda. Before doing developing the agenda, I wanted to provide my observations about the status of the group given some of the frustrations some of you have suggested.

Currently, the group is facing what is often referred to as the Groan Zone, a place where divergent thinking and convergent thinking collide. Some of you want to narrow in on a decision; others want and need better data from which to make a recommendation. It is a natural point for a stakeholder process. Many stakeholder processes spend a good year or more, gathering data and discussing their reactions to the data and implications of the data. Your task from November until now was to look at the biological considerations; my question to you now is do you feel that we have done a good enough job in looking at that aspect? I'd like to hear about where you would like to head in February. Tom has suggested evaluating the classification system; Judy has proposals for you as well as others. You all have started to create a framework for discussion in order to learn about what each other is thinking with respect to some of these items. Some deliberations, perhaps a trial balloon, will help you all build a path forward. For the Nov and Jan discussions, you wanted to focus solely on biological considerations? Treat the biological discussion as part of an iterative process in moving forward? What do you want for Feb agenda?

Frustration with Process:

Some of our frustration is that we're trying to use science and yet we don't have a pot of money to throw at someone to say, "Go off and do this." Instead, we are relying on someone else to fund a study; this gets at the whole issue of timeframe and control over what we're doing as opposed to relying on other efforts. We may not be able to do anything about that but if we generate good ideas, hopefully there is a way to get those answers in a timely manner. Some of the stuff we know there is not going to be an answer out there, other things, if we want an answer; we'll need to spend time and money to determine (whether from this group or another).
Paraphrasing Chris, currently the EFSAB has been developing a framework for analyzing the issues before you, pointing out potential holes or gaps in knowledge, and identifying potential partners that have gathered or are gathering data to contribute to the larger knowledge base. The knowledge you all work with may come from the EFSAB table or from other sectors. Chris suggested that with the other efforts going on, particularly the two LCC's doing the same kind of work, e**veryone is looking to everyone else to get it done; the frustrations and complexity to all this are not confined to this room - everyone across the Southeast and really across the country are dealing with this.**

Future Topics and Other Considerations

1. **The Fidelity Study (2 hours if possible with question/response)**
    - Ensure others are familiar with the details of the study (some may not be as we continue to figure it out).
    - Attempt to determine whether or not, species and guilds show a strong degree of correlation with our classification system.

- In preparation, we have determined what data are available (in partnership with Mary Davis and Cat Burns, both who expected to line up data). We are pulling data together for several projects under one initiative with a good idea of what data is available and the quality of the data.
- Currently, we are in the process of looking at strategies for testing fidelity. The RTI already has an internal project going on to look at similar questions over a very large region, we've been talking with them about the possibility that they might tag this onto what they were already doing in order to look at how the data about species and guilds line up with our classes.
- My working hypothesis is that they will not line up particularly well but that they will line up. Suspect we may find multiple clouds of species and guilds that show fidelity to our big classes; that we'll then be challenged to subset those large classes into smaller classes based on those multiple clouds of coordinating organisms from guilds. The kinds of data that could be used, the kinds of variables that could be used to subset are principally topographic--that is, variables associated with the substrait and with the shape of the land.
    - My working hypothesis is that we will be able to subset our classes into a larger number of classes for which organisms and guilds show a relatively high degree of fidelity. I'd like a chance to present it to you all and see what you think.
- Range of Taxa available includes: Heritage Study (using rare critters, mostly animals that are found in North Carolina's rivers and streams; DWQ (bug data); WRRI (unsure), Wildlife Resources Commission (Fish and bugs, mainly fish I think - there's been this large pool of data collected for multiple projects to take advantage of and we're now hoping to use it); and we also have trout data.
- Fidelity Analysis: for our Feb discussions, would like to hear the groups' thinking in terms of the Fidelity Analysis. What comes to mind for me is the whole reference site issue, that when you get into the biology and fidelity for these particular hydrologic classifications, these are sites based, chosen because they have no impacts hydrologically, and if you're matching those up, need to consider your reference conditions; otherwise, you throw in all the water quality problems and all the channel alterations, and we could wind up with a mess.
- We are getting data from multiple sources, collected under different sets of constraints. The DWQ data was collected in wadeable streams; Heritage data, for the most part was concentrated where roads cross-rivers.
- Although the data may be severely limited, it is the data we have. When we consider the data, suggest we try to determine if there are any sorts of filters or screens to put the data through.

2. Classification Discussions (focus of next meeting):

- The whole process of evaluating the classifications is not just about biofidelity, it's also about what else do we know about these groups, these classes that might affect the interpretation of eco-flows? That might be something like soil types, land use types, the types of things we normally use to explain biological behavior. It's not will we go out and get this information now - it's really: *Do we have this information? Where are the gaps? Where are the sources?* Maybe someone else is already dealing with what we are and can respond to a question. I'd feel a whole lot more comfortable if I knew what we have and what we know about these classes in order to say, yes, this makes sense; these are the things that would be important for driving hydrology and the ecological responses.

- Other efforts are dealing with those very issues. Mary Davis is certainly doing the bulk of it, Konrad is involved, and the Northeastern classifications; these efforts are looking at or have looked at other parameters. At some point, particularly if Mary Davis's work is going to have a product in the next couple of months, we may want to hear from Mary again to let us know: "This is what they have found in looking at various classifications, particularly as it relates to North Carolina and more broadly."
    - If there is general interest in hearing more about the Northeast and Mid-Atlantic TNC classification mentioned earlier, I can figure out a way to get a presentation through a webinar or something if we decided to review different classifications (Cat Burns).
- In addition to the EFS classification, we're also looking at Konrad and McManamay so we're going to look at three separate classifications.

3. Biological Discussions (ongoing; will raise specific topics as needed):

- Let's ensure we include our biological perspective as an iterative component to what we are learning about these classification systems and compare those back to the hydrologic classification as we begin to peel off more layers of this onion, just to understand collectively as a group how these things vary with flow. I want to ensure we continue our biological discussions and keep the ecology in ecological integrity as long as we can.
- When we have a set of classes that we like, whatever means we arrive at for that set of classes, that for each class we then identify which are the most sensitive species and/or guilds for each of those classes and use those sensitive species or also indicator species; use them to craft the ecological prescription for each class. That way you are writing the most conservative prescription for each class. That's just a strategy that's been put on the table many times over the last 3-4 months. It's not mine alone; it's something that's been floated periodically. I don't know that we've looked at alternatives to that strategy for getting from classes to prescriptions but I'm sure there are alternatives.
- From what Judy said earlier today, if you break it down into two or three major steps: those being review the approach for classification, review the classification, and evaluating fidelity, etc. That's step one. If we all agree, that that's written into our task I think you put it on every agenda as to what our charge is really.
    - The second, of course, is to look at methods to determine flows needed to maintain ecological integrity, which is: What's an acceptable level of change to maintain integrity? What are we willing to accept that is "a change" within a habitat or a guild or whatever such that we are in agreement that ecological integrity is maintained? Is it zero or is it 20% or 30%? Whatever the metric is that's built into that, recommending the method you have to make that assessment and then we can decide which method gives us the best integrity.
    - If we agree that those are the tasks and break them down, that's pretty much the gist of the questions that have been brought up about what we're charged with doing.
- I want to point out Tom Reader presentation today gave us a perspective that I didn't feel we had before. For one thing, I was not aware of the 20% 7Q10 threshold, and how that would be used with the model. This has helped me recognize we may have a much longer timeline than I thought at the November meeting.

- Items for future discussions proposed by Judy (natural flow regime, presumptive standard, adaptive management?) These are definitely up for discussion and the comments made today have been helpful in addressing those.

4. Revisit the Charge (break into steps; no urgency for presumptive standard discussion):

- A discussion on the charge was planned in October but for lack of time, this agenda item was postponed. Do you want to revisit the charge (what it says; the legislative language) to help put into context?
- The difficulty in October was whether we were going to revisit the classification system being proposed and we're definitely been doing that (we're charged with classification as well as ecological flow recommendations (our methodology)). In the beginning (I believe) people felt were we really addressing methodology and not addressing whether or not we had the right classification. I think we are that path (and the reason this came up in October).

5. Additional Scenarios from Jim

- Discussion point- is Jim ready to provide additional scenarios.
    - One member suggested holding off until later in the year in order to look at several scenarios at one time
- I'm more interested in the question about your color-coded stream regions. If there's a basin: Neuse, Cape Fear, small portion of the Cape Fear where we could see how frequently we see changes in classification within a given stream network. This could be very useful information.
- Not going to happen fast because there are technical challenges to that presentation (Jim will review scenarios and color coded process to determine what can be presented in Feb).

6. Preparation/Homework for meetings

- When it has been possible, Jim has emailed a link to online reading materials. If a link is not available, it is more difficult to distribute unless the author grants permission to the EFSAB for EFSAB use.
- I prefer that as soon as you know the reference to send it out (and I will track the article, especially if you have the DOI number)
- Lou will check options available at NCSU

7. Feb 21 Meeting (hours needed) 10-4pm. Bring your own lunch or purchase downstairs.

We appreciate you all attending today and thank Tom Reeder for coming in. The hope is that it was very helpful to hear about how your work is being valued.